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55TH CONGRESS, 3d Session. } SENATE. { REPORT No. 1433.

REPORT

ON THE

MISSISSIPPI RIVER FLOODS

BY THE

COMMITTEE ON COMMERCE,

UNITED STATES SENATE,

PURSUANT TO

SENATE RESOLUTION NO. 76, FIFTY-FIFTH CONGRESS, FIRST SESSION.

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55TH CONGRESS, 3d Session. | SENATE. | REPORT No. 1433.

FLOODS OF THE MISSISSIPPI RIVER.

DECEMBER 15, 1898.—Ordered to be printed.

Mr. NELSON, from the Committee on Commerce, submitted the following

REPORT.

[To accompany Senate Res. No. 76.]

The Committee on Commerce makes the following report of the action of the committee, taken pursuant to the following resolution:

Resolved, That the Committee on Commerce is hereby instructed to make full examination and inquiry as to the following questions and report thereon to the Senate, by bill or otherwise, on the first day of the regular session in December next:

First. What are the causes of the disastrous floods in the Mississippi River and its tributaries, and how can such floods be prevented or diminished?

Second. If such floods are the result to any extent of the destruction of timber upon or near the head waters of said river or its tributaries, what measures should be adopted to prevent such destruction, and whether reservoirs to hold the water caused by rain or the rapid melting of snow on or near said head waters should be constructed to prevent the floods caused by the sudden precipitation of the rain or snow water into the streams flowing from the regions where the sources of the Mississippi and its tributaries are located.

Third. Whether said reservoirs, if their construction should be deemed necessary for the purposes before set forth, could not also be utilized for the irrigation of arid lands in the vicinity of such reservoirs.

Fourth. Whether the outlet system by which it is proposed to furnish avenues through which the waters of the Mississippi River can escape in times of flood is practicable or expedient.

Fifth. Whether the present system of improving the Mississippi and Missouri rivers under which it is sought to confine the water within the banks of said rivers, by means of levees, and by such levees, together with jetties at different localities, to increase the erosive power of the current so as to protect the banks and deepen the channel, should be continued.

Sixth. What has been the effect upon navigation and commerce of the jetties at the mouth of the Mississippi River, and what is the present condition of said jetties and their probable future?

Seventh. Whether the Mississippi and Missouri River commissions should be continued in existence, and, if continued, what amendments should be made to the statutes creating such commissions and defining their duties and powers.

Eighth. What legislation is necessary to prevent the enormous destruction of property by floods in the Mississippi River and its tributaries, and what amount of money should be appropriated by Congress for the establishment and maintenance of systematic improvements and safeguards for said purposes?

That said committee shall have power to prosecute its inquiries through a subcommittee, which may sit during the recess of the Senate at such times and places as may be thought necessary, with power to send for persons and papers, and to employ a stenographer, the expenses of said committee to be paid from the contingent fund of the Senate.

The investigation contemplated by the resolution was carried on through a subcommittee composed of Senators Nelson, Elkins, Vest, McBride, Gallinger, Berry, and Caffery.

In October, 1897, the subcommittee visited the reservoirs at the head waters of the Mississippi, also St. Paul, Rock Island, and St. Louis on the Mississippi River, and Sioux City on the Missouri River, and took the testimony hereto appended. In February, 1898, the subcommittee went to Cairo, Ill., and from there on the Mississippi River down to the Gulf of Mexico on the boat of the Mississippi River Commission, and on this trip took the residue of the testimony hereto appended. The testimony so taken is comprehensive and instructive, covering every feature of the contemplated inquiry. In addition to the facts and data derived from the testimony, your committee have also derived much valuable information from a pamphlet on The Floods of the Mississippi River, by William Starling, chief engineer of the Lower Yazoo levee district, 1897, and from Bulletin E of the Agricultural Department on the Floods of the Mississippi River, prepared by Park Morrill, under the direction of Willis L. Moore, Chief of the Weather Bureau, 1897. The pamphlet will be cited as "Starling," and the bulletin as "E."

The questions propounded for the investigation of the committee are to a large extent questions of science and engineering, and the committee can do little more than to briefly summarize the opinions and conclusions of experts.

CAUSES OF THE FLOODS.

The principal territory submerged or affected by the floods of the Mississippi River before the construction of levees, and in part since, consists of certain basins or bottoms along the banks of the river between Cairo and Forts Jackson and St. Phillip. These basins, from Cairo down, are as follows:

The St. Francis Basin, on the right bank of the river, extending from Cairo to Helena, near the mouth of the St. Francis River, and embracing an area of about 6,706 square miles;

The White River Basin, on the same side of the river, extending from Helena to near the mouth of White River, and embracing about 956 square miles;

The Yazoo Basin, on the left bank of the river, extending from a short distance below Memphis to a point near the mouth of the Yazoo River, and embracing, in all, about 6,648 square miles;

The Tensas Basin, on the right bank of the river, extending from near the mouth of the Arkansas River to near the mouth of the Red River, and embracing an area of 5,370 square miles;

The Atchafalaya Basin, on the same side of the river, extending from the junction of the Red and Atchafalaya rivers to Fort Jackson, and embracing 8,109 square miles; and

The Pontchartrain Basin, on the left bank of the river, extending from Baton Rouge to Fort St. Phillip, and embracing an area of 2,001 square miles.

The aggregate area of all these basins is 29,790 square miles, or 19,065,600 acres. (Test., 431.) Ever since the immediate valley of the river below Cairo has been settled there has been a constant struggle to reclaim these basins and to protect them against overflows and floods. The problem has been in part accomplished, chiefly by means of levees, but much still remains to be done. The ultimate object of this investigation was to determine the best method for the complete

and permanent protection of these basins against the floods and inroads of the river.

The Mississippi River at Cairo is composed of the waters of the Ohio, the Upper Mississippi, and Missouri rivers. The Ohio and its chief tributaries have their sources in the western slopes of the Allegheny Mountains and their spurs. The Upper Mississippi and its principal tributaries have their sources in numerous lakes in that plateau of land between the Red River of the North and Lakes Michigan and Superior, and the Missouri has its source in the upper eastern slopes and foothills of the Rocky Mountains. The White and the St. Francis rivers, with sources in the Ozark Mountains, in southern Missouri and northwestern Arkansas, and the Arkansas and the Red rivers, with their sources in the lower eastern slopes of the Rocky Mountains, contribute considerable volumes of water to the Mississippi River within the basins subject to overflow.

The annual normal rainfall in the different river basins varies greatly. In the Ohio it is 44.2 inches; in the Upper Mississippi, 31.9; in the Missouri, 19.4; in the Arkansas, 29.6; in the Red, 39.1, and in the central valley of the Mississippi, including the White and the St. Francis, 51.4 inches (E, 24 and 25). In the Upper Mississippi and the Missouri the rainfall is, as a rule, greatest in May and June. In the Ohio and the central valley it is greatest in January, February, and March (Starling, 22 and 23).

The greatest and most destructive floods have generally come from the Ohio. This was the case with the great floods of 1882, 1883, 1884, and 1897; and these floods culminated in February or March (E, 40–45, and Starling, 29 and 41). Of the total amount of water passing Cairo during these floods the Ohio contributed 69 per cent in 1882, 70 per cent in 1883, 85 per cent in 1884, and 76 per cent in 1897 (Starling, 27 and 41). These great floods from the Ohio River, like all similar floods, came from excessive rains in the basin of the Ohio and its tributaries. These rains arise from cyclonic storms and warm, moisture-laden winds, originating in the Gulf of Mexico, and passing thence up the central valley and the valley of the Ohio into the western slopes and spurs of the Allegheny Mountains, where a colder atmosphere is encountered, leading to the precipitation (Test., 267).

The Ohio floods, after passing Cairo, are frequently largely reinforced by floods from the White and St. Francis rivers and other streams in the central valley. Occasionally the floods from the Missouri and Upper Mississippi are, to a limited extent, a factor in extending or prolonging the flood on the lower river, but this applies rather to the May and June freshets of the Ohio than to the earlier and more extensive ones (Starling, 24 and 25).

In Bulletin E (p. 46) the "Cause of the Mississippi floods" is thus summarized:

> It is, of course, conceivable that a flood should occur in the Lower Mississippi from heavy precipitation over any of the great contributary basins. In these floods of the past quarter century we do not, however, find the western tributaries playing an important part. The great source of floods is the Ohio Basin, with its steep slopes from the crest of the Alleghanies, upon which falls the heaviest rains of spring at a time when the normal rise of the Lower Mississippi brings the river almost to the danger line from Cairo to the Gulf. In the greatest floods we also find that heavy rainfall over the great swamp region that extends along the Mississippi from the mouth of the Ohio to the Gulf of Mexico is an important factor. Third in importance as a factor in producing floods is the Upper Mississippi, which, while never discharging a volume sufficient to produce of itself a flood, yet, rising later than the Ohio, serves to prolong the high water, and thus to increase the overflow.

There are other causes, to which we shall refer further on, which have tended more or less to aggravate the destructive features of recent floods, but the foregoing presents briefly, and in a general way, the primary and chief cause.

DESTRUCTION OF FORESTS.

Nothing in the evidence or other data obtained by your committee discloses the fact that the destruction of timber at or near the head waters of these river systems tends to cause or promote the floods referred to. It was shown that where timber is cut down for purposes other than cultivation the underbrush remains and grows more luxuriant than ever, and such underbrush serves to retard rather than hasten the movement of water on the slopes and hillsides; and where timber is cut down for purposes of clearing and cultivation the plowed area becomes an enlarged absorbent of surface moisture: It is a generaly accepted opinion that the destruction of timber tends rather to diminish than to increase the rainfall.

RESERVOIRS.

There are five reservoirs constructed at the head waters of the Upper Mississippi. These reservoirs repress to some extent the floods in the river bottoms above Lake Pepin and improve the navigation of the river in low water down to that point, but have no material effect upon the floods or navigation of the river below that point. The evidence discloses no other points on the Upper Mississippi available for reservoir purposes. On the Missouri the only point where sufficient holding ground could be found for a reservoir of any magnitude is on a reach of the river above Great Falls. Such a reservoir, if constructed high enough to bring the waters of the Missouri River into the Milk River Valley, would be valuable for purposes of irrigation, but would have no material bearing on the floods in the Mississippi River, nor on the navigation of the Missouri River.

The evidence, as well as the other data, discloses that on the Ohio River, as well as its main tributaries, where reservoirs could act more directly on the floods than elsewhere, with the exception hereinafter stated, there are no suitable sites or holding grounds where reservoirs could at any moderate or reasonable expense, and without working far-reaching and extensive damage, be constructed that would at all be adequate to pen up and retain the great downpour from innumerable mountain torrents during the great freshets of January, February, and March. There are no great basins adequate for reservoir purposes either on the Monongahela, the Allegheny, the Tennessee, or the Cumberland; and to be effective in repressing the floods of the Ohio, big, strong reservoirs would be requisite on these streams.

The only place where a reservoir basin can be found, proximate and sufficiently large to afford a holding ground at all commensurate with any material or practicable relief, is the St. Francis Basin; but the cost of constructing and maintaining a system of reservoirs in this basin would be enormous, and far greater than the cost of leveeing the entire river front of the basin. The scheme is regarded by nearly all engineers and other experts as wholly impracticable. In short, your committee can discover no just or adequate relief in reservoirs.

OUTLETS.

Neither can your committee discover from the evidence, or through other sources, any material relief from the outlet system. It is not practicable to relieve the river by means of outlets except below the Red River. Two important natural outlets now exist and have for years existed on this reach of the river—the Atchafalaya and Bayou Lafourche. A third, Bayou Plaquemine, is now closed pending its preparation for reopening by means of locks and dams. But these outlets, or others that might be constructed on this reach of the river, could afford no perceptible relief for the river above, where relief is much more called for and needed. The St. Francis, Yazoo, White, and Tensas basins can get no relief from any practicable outlet system. And where this system exists and is feasible there is no disposition to extend it or to substitute it for levee enlargement. (Test., 424–455, 335, 375; see also Humphrey and Abbott's report of 1861 as to reservoirs and outlets.)

LEVEES.

The history of levee construction on the Mississippi River has been a history of the gradual reclamation of the several basins or bottoms from the inroads of the floods of the river. Anterior to levee construction these basins served as great natural reservoirs for the floods, the exterior hills or ridges of the basins serving as the high-water banks of the river; and within these banks so wide apart and with these basins for a high-water bed, the floods never reached the high level nor the increased rapidity obtained since the great extension of the levee system. Levees are the penning up of the floods of the river from these high-water basins. The narrowing of the high-water stream by means of levees does not result in materially scouring a deeper channel nor in raising the bed of the river (Test., 269), and so the stream at its flood stages, as it becomes narrower, also becomes higher. Contraction without deepening of necessity leads to elevation, and as a consequence levee construction has brought in its wake higher flood levels, necessitating from time to time higher and stronger levees. The history of levee construction shows this. (Dabney, Test., 311; Driver, Test., 199; Starling, Test., 269; Gillespie, Test., 382, 383; Newcomer, Test., 334; Richardson, Test., 370, 371; Taylor, Test., 237, 239, 241; Table, Test., 432; Tollinger, 510.)

The first levee construction began in 1717, when a levee 1 mile long was constructed to protect New Orleans, then a mere village. This levee was 4 feet in height and 18 feet across at the top. The country settled up slowly, and levee construction only kept pace with the settlement. Fifty years after this levee was built the settlements extended only 30 miles above and 20 miles below the embryo city. It was not until after Louisiana had been ceded to the United States that levee extension was undertaken on an enlarged and systematic scale. By 1828 the levees, though of rather inferior character, had been extended nearly up to the mouth of the Red River. At the beginning, a levee 4 feet in height was ample, but as levee construction progressed up the river, and additional basins and bottoms were inclosed and protected, the levees were, of necessity, increased in height (Test., 237). There are still levees below New Orleans that are only from 3 to 4½ feet in height, but the average height of the levees in Louisiana, above New Orleans, is now from about 12 to 13 feet (Test., 380, 369), and this height proved insufficient in the great flood of 1897 (Test., 370).

The flood stage of 1897, above New Orleans, was from 1⅓ to 3½ feet higher than that of any previous flood, notwithstanding that the flood level at Cairo was less than in 1882–83 and 1884. Three great crevasses occurred in 1897 that remained unrepaired until after the flood subsided, and several minor crevasses occurred, which were closed during the pendency of the flood. This increased flood level was "partly due to the improvement and increase of levees." (Test., 370, 371, 380, 423, 424.) The experience of 1897 indicates that a complete inclosure of all the river basins will require from 3 to 4 feet higher levees in Louisiana.

The levees on the Yazoo Basin were only 4 feet high in 1858. From 1874 to 1882 they were raised to from 7 to 8 feet (Test., 269–308), which proved insufficient under the flood of 1882; and based on this flood as a standard, the levees were increased to an average of from 13 to 14 feet in height prior to 1897. This was more than 3 feet above the high water of 1882 (Test., 308–311), but it proved utterly insufficient under the flood of 1897.

Since the floods of 1882–83 and 1884 the White River Basin, the Upper Tensas Basin, and much of the St. Francis Basin have been inclosed, and this, together with the higher levees on the Yazoo front, have greatly aggravated and raised the flood levels on this reach of the river. (Test., 269, 272, 273, 311.) The flood of 1897 made it plain that a complete inclosure of all the river basins would require an increase of from 4 to 6 feet in height of the Yazoo levees. (Test., 274–275, 311; see Starling's paper on levee construction in Yazoo Basin, Test., 505–508.)

The work of inclosing the White River Basin was commenced in 1888, and most of it was done after 1890. By 1897 the basin had been inclosed by a levee of an average height of 12 feet, deemed sufficient under the flood levels of 1882–83 and 1884, but this proved utterly insufficient in the flood of 1897. That flood overtopped the levee at many points, and was from 4 to 6 feet higher than any previous flood, clearly indicating that a complete levee system along the entire river would require an increase of 6 feet in the levee height along this basin. (Test., 301, 302.)

In the Upper Tensas Basin nearly all levee construction has taken place since 1882—mainly since 1892. In the Lower Tensas Basin there was an old levee existing before this period, but of low grade and insufficient in strength. By 1897 the Upper and Lower Tensas Basin levees had attained an average height of 13 feet. In the flood of 1897 the river was from 2½ to 3 feet higher in front of these basins than in the flood of 1882, and hence the levees were insufficient. Had the water in 1897 not been any higher than in the floods of 1882–83 and 1884, the levees would have been ample. (Test., 330–332.) Several serious crevasses occurred in these levees during this flood. The higher flood level of 1897 was largely due to increased levee construction and the further inclosures of river basins. (Test., 334.) The completion of the levee system would require the levees on the Tensas Basin to be raised to the height of from 17½ to 18 feet. (Test., 334, 335.)

In the St. Francis Basin levee construction began in 1893. Since that time a continuous levee of an average height of 9 feet has been constructed from Point Pleasant, Mo., to Chute 38, Arkansas, a distance of 127 miles. About 100 miles more are required to reach the mouth of the St. Francis River and to entirely inclose the basin. The levees on the St. Francis Basin proved insufficient for the flood of 1897, and several serious and extensive crevasses occurred. These levees need to be made

stronger and higher—at least 2 feet higher than the grade of 1897. (Test., 167–170.)

The flood of 1897 wrought great havoc, especially in the older levees, many of which had been defectively and improperly constructed. There were 23 breaks in the St. Francis front, 6 in the Yazoo front, 14 in the White River front, and 4 in the Tensas front, most of which occurred from an overtopping of the levees. Below the Red River there were only a few small breaks, and these were closed during the pendency of the flood. (Test., 432) Engineer Ockerson in his testimony (p. 432) describes the flood of 1897 and compares it with the flood of 1882 as follows:

From a point about 100 miles below Cairo to the Gulf the stage reached in 1897 was greater than any previous record. As far as volume of water is concerned, however, the flood of 1882 was much greater than that of 1897. The flood of 1882 stood above the danger line at Cairo, or 42 feet on the gauge, for a period of seventy-two days. The flood of 1897 stood above the danger line for a period of fifty-four days. During the flood of 1897 the tributaries below Cairo were all rather low.

Table showing relative heights of floods of 1882 and 1897.

	1882.	1897.
Cairo	51.9	51.6−0.3
Belmont	45.1	45.1 0.0
New Madrid	40.9	40.3−0.6
Cottonwood Point	37.5	39.3+1.8
Fulton	36.7	37.5+0.8
Memphis	35.2	37.7+2.5
Mhoons	39.8	41.6+2.8
Helena	47.2	51.8+4.6
Sunflower	41.7	47.3+5.6
White River	48.4	52.4+4.0
Arkansas City	47.1	51.9+4.8
Greenville	41.7	46.8+5.1
Lake Providence	38.3	44.4+6.1
Vicksburg	48.8	52.4+3.6
St. Joseph	44.9	47.9+3.0
Natchez	47.8	49.8+2.0
Red River	48.5	50.2+1.7
Bayou Sara	39.3	43.8+4.5
Baton Rouge	36.0	40.7+4.7
Plaquemine	31.3	36.3+5.0
College Point	23.2	28.0+4.8
Carrollton	15.0	19.0+4.0

A due consideration of the testimony and other data bearing on the subject makes it clear that the flood of 1897 was, in its effects and consequences, greatly enlarged and aggravated by the extensive inclosure of basins and the extended and enlarged levee construction that had taken place since the floods of 1882–83 and 1884 (Test., 241), though it is doubtless true that if no levees at all had been in existence a larger area would have been submerged. Engineer Starling, in his book (41, 42), to which we have already referred, concurs in this conclusion in the following clear and apt language:

It is not only the magnitude of the flood of 1897 which has made it of surpassing importance to the engineers of the Mississippi service. The widespread damage which it has wrought, while great, is yet not without a parallel. Its principal interest to the engineer is due to the experience which has been derived from the wholesale closure of unleveed tracts and the extraordinary elevation of its high-water line consequent thereon. There are two of the great basins into which the Mississippi Valley is divided which have only recently been protected to any extent by levees. These are the St. Francis and the White River basins. The former was closed during the last three years, or since the flood of 1893, to a distance, measured along the river, of about 120 miles. There still remains a gap of about 100 miles. The White River Basin has been undergoing a gradual process of closure for several years. In

1893 there was a gap of about 15 miles, extending between points 330 and 360 miles, respectively, by river, below Cairo. In 1896 this gap was closed and the line of levee was made continuous from the hills at Helena to a point 8 miles above the mouth of White River. It is to the building of these lines and to the maintenance of the lines previously existing until a late period of the flood, that the unparalleled stages attained by the water have been due.

The construction and repair of levees was, in the first instance, undertaken by riparian owners, afterwards by parishes or counties, then by the States or certain levee districts, under the authority of the States, and finally by the latter and the Federal Government combined, which is the system now prevailing. The first material aid given by the Federal Government was a grant of swamp and overflowed lands; made to the several States in 1850. The same year Congress also made provision for a survey and investigation of the Mississippi River.

This work was carried on for the next ten years under the direction of Captain Humphrey and Lieutenant Abbott, who made their final report in 1861. This report was most thorough and exhaustive, and is still the standard work on the hydraulics and physical features of the river. It made clear that no substantial relief from floods could be obtained from reservoirs or outlets, and that levees, properly constructed, would afford the necessary relief and protection. Neither the testimony taken by your committee, nor other obtainable data, has shaken or invalidated these conclusions. During the civil war levee construction was at a standstill. After the war was over the several States began, without concert and without due plan or system, to extend and repair the levees. But the great flood of 1874 showed how inadequate, both in quality and quantity, the efforts of the States were. Congress again intervened, and passed an act providing for the appointment of a commission of five engineers to investigate, determine, and report as to the best plan for relief against the floods.

This commission made its report in 1875, and came to the same conclusion as Humphrey and Abbott did in 1861, that a system of levees could alone afford adequate protection. But no systematic improvement of the river by the Federal Government was yet undertaken. Finally, in 1879, Congress passed an act creating the Mississippi River Commission, outlining its work in the following terms:

It shall be the duty of said commission to take into consideration and mature such plan or plans and estimates as will correct, permanently locate, and deepen the channel and protect the banks of the Mississippi River; improve and give safety and ease to the navigation thereof; prevent destructive floods; promote and facilitate commerce, trade, and the postal service.

From 1879 to 1882 $1,475,000 was appropriated by Congress for expenditure by the commission in making surveys and in improving the navigation of the river, but none of it was allotted for levee construction. In 1882 Congress appropriated the gross sum of $4,123,000, and from this the first direct allotment for levee construction was made—about $1,300,000 in all. (Test., 237.)

The testimony of Judge Taylor, a member of the commission, explains in detail the make-up of the commission, the mode in which it performs its work, and the methods it pursues. From each appropriation made the commission allots a certain proportion for the construction and repair of levees in each levee district, which is expended by the United States engineer in charge of the district. The commission plans the work, subject to the approval of the War Department, and the district engineers carry on the work conformable to the plan.

The first effort of the commission was directed to the closure of the Yazoo Basin, and then followed the improvement of the Tensas Basin,

then the White River Basin, and, finally, a part of the St. Francis Basin. In the respective levee districts the State and Federal engineers, while acting in concert and harmony as far as possible, work each on separate and distinct portions of the river. One reach is constructed under Federal authority and another under State authority. When a levee is constructed, the constructing engineer or his successor takes charge and care of the same. (Test., 257, 258.) In case of an emergency there is by mutual consent a sort of joint care and supervision. As a rule, both Federal and State engineers are men of fine attainments, high character, and great public spirit, which tend to obviate any friction that otherwise might ensue from an undefined joint tenancy. It would no doubt be advisable to provide by law in which authority the care and maintenance of a constructed levee should vest.

The evidence (p. 518) discloses the fact that 18 suits have been brought against the United States for damages claimed to arise from the construction and maintenance of levees or failure to construct or maintain proper levees along the Mississippi River. The aggregate amount of damages claimed in these suits is $656,337.04.

From a table (following p. 518 of testimony) prepared by Captain Waterman, secretary of the Mississippi River Commission, under the direction of General Gillespie, president of the commission, it appears that the total yardage of levees constructed by Federal, State, local, and private authority is 164,860,375 yards, built at a cost of $47,631,503.78, of which yardage 68,570,431 yards were constructed by Federal authority, at a cost of $13,320,708.44, and 96,289,944 yards by State, local, and private authority, at a cost of $34,310,795.34.

It is estimated that it would cost to complete the entire levee system, from the head of the St. Francis Basin to the Head of the Passes, at a grade sufficiently high and strong to afford complete protection against floods at the highest probable stages, the sum of from $18,000,000 to $20,000,000, and that it would take from four to five years to complete the system. (Test., 245, 246, 390, 396, 408, 357, 360.)

From all the evidence taken and considered by your committee it is evident that the basins and bottoms along the Mississippi River exposed to the floods of the river can only be protected and preserved from such floods by an ample and complete system of levees from Cairo to the Head of the Passes.

Crevasses and inundations, resulting in extensive loss of life and property, are liable to occur during all floods so long as the system is incomplete. The burden of completing the levee system is too great for local and State authority. Your committee are of the opinion that the Federal Government should continue, as it has since 1882, to aid in the great task of controlling and repressing the floods in the river.

Your committee are also of the opinion that the Mississippi River Commission should remove its principal office and headquarters from New York City to some point on the Mississippi River.

NAVIGATION, MISSISSIPPI RIVER.

The testimony discloses that the navigation of the Upper Mississippi River has been considerably improved by the reservoirs, on the reach above Lake Pepin, and by riprapping, wing dams, spur dikes, hurdles, revetment works, and a little levee work at various points on the river below that reach. (Test., 20–34.)

The Mississippi River Commission has carried on more or less extensive improvements of the navigation of the river on many of the reaches below Cairo. Such improvements, in addition to levee work, have consisted of bank protection in the form of riprapping and various kinds of revetment work, of channel contraction by means of jetty work, hurdles, and various forms of spur dikes, and of dredging on an extensive scale. Some of the work has been rather tentative and of a temporary character, and on account of the great cost has not been followed up.

At present, aside from levee work, the chief reliance for obtaining a low-water navigable channel seems to be dredging. The new style of hydraulic dredges seem to be very potent and effective, and seem to give great and promising results. Four new dredge boats have been for some time completed and in use, and two more are under contract and by this time ready for use, and there is money available for another dredge. It is estimated that from nine to ten dredges will be required to keep a due low-water channel open. (Test., 100–108, 140–148, 218–235.) In the light of results obtained, your committee recommend that ample provision be made for, the construction of dredge boats, and dredging. In view of the great cost, especially great as to results, it seems that it would be more judicious to limit revetment work to levee and harbor protection. Contraction, by means of jetties, dikes, and dams, supplemented by dredging, seems to have given the best results at least cost. There is no doubt that revetments are very efficacious, but the cost is so immense that its systematic application is scarcely warranted.

JETTIES AND PASSES.

As the Mississippi River in its downward course is about to debouch into the sea it divides itself into three great passes, through which it enters the Gulf, and forms the delta at its mouth. These passes are known as the Southwest Pass, South Pass, and Pass a Loutre. From New Orleans down to the Head of the Passes there has been no impediment to deep-water navigation. The impediment occurs in the passes, especially at their heads and mouths, chiefly the latter. Prior to the improvement of the South Pass by means of jetties, navigation was chiefly confined to the Southwest Pass, though Pass a Loutre had for some years been utilized to some extent.

In 1839, when the Southwest Pass was first examined, it was 15.2 miles long and 13 feet deep on the crest of the bar, and it was then, as now, of an average width of twice the width of the South Pass. Between that time and 1877 considerable work was done in improving this pass, but such work, aside from a short and abortive jetty work on one side of the pass in 1856, consisted of dredging and stirring up the bed of the channel by means of drags, harrows, scrapers, blasting, torpedoes, and other similar appliances. By these means a depth of 18 feet was at one time, for a short period, obtained on the crest of the bar. In 1874, the year before the improvement of the South Pass began, the Southwest Pass had attained a length of 18 miles, with a depth of only 15 feet on the crest of the bar, and on the 9th day of February last the pass had attained a length of 18½ miles, with only a depth of 9 feet on the crest of the bar, according to soundings then taken. (Test., 464.)

In aid of the improvement of the South Pass Captain Eads placed a mattress sill across the head of the Southwest Pass, which, aside from

a little dredging prior to 1878, is the only improvement made in this pass since 1875.

Prior to 1875 like efforts at improving Pass a Loutre, except jettying, were also made, which were, in like manner, partially successful. By the fall of 1858 an 18-foot channel had been obtained in this pass, and for some years it was, on account of being the shorter pass, utilized for purposes of navigation; but in 1875 the channel was destroyed by a large mud lump, and since that time no improvement has been made, except placing a mattress sill at the head of the pass and the work of attempting to close a large crevasse on the south side of it near the upper end, both of these works being in aid of the maintenance of the South Pass jetty system.

The South Pass in 1838 was 11.3 miles long, 700 feet wide, except at the extremities, and 8 feet deep on the crest of the bar. In 1875 it was about the same length and width, but only 7 feet deep on the crest of the bar. In 1874 a board of engineers, consisting of 3 army engineers, 3 civil engineers, and 1 from the Coast and Geodetic Survey, was appointed to devise and determine upon some plan of securing deep-water navigation through one or more of the passes. This board, after visiting Europe and examining many works there involving similar problems, recommended, in January, 1875, the improvement of the South Pass by means of jetties. In pursuance of this recommendation Congress, in March, 1875, conferred the task of making the improvement upon James B. Eads and associates. The jetties were practically built on lines recommended by the board.

The original act provided for a channel 30 feet deep and 350 feet wide, but by 1878 it became evident that such a channel could not be obtained by the work then laid out, and accordingly Congress was induced to remit, by acts passed in 1878 and 1879, the requirement to a channel 200 and 250 feet wide and 26 feet deep, and on this basis the work was deemed completed in July, 1879. In making the improvement, and as a part of it, training dikes were built at the Head of the Pass, and mattress sills were laid at the head of the Southwest Pass and Pass a Loutre. In 1891 the west end of the Pass a Loutre sill was carried away, and a large break occurred on the west bank of Pass a Loutre about 1½ miles below the head of the South Pass.

This break, although several attempts have been made to close it, has not yet been closed, and in consequence thereof, as well as on account of the loss of the contiguous end of the Pass a Loutre mattress sill and portions of the training dikes, and lack of repair and maintenance in some of the training dikes, the inflow of water into the South Pass has been less than before, which has, no doubt, to some extent detracted from the scouring force in the pass, necessitating some dredging, for the maintenance of the requisite channel. Before these drawbacks occurred the pass received from 10 to 11 per cent of the water in the main stream; since then only 7 per cent. Three hundred feet of the jetties at the sea end have been washed away on both sides, and in addition to this 150 feet of the jetty on the west side. None of the jetties thus washed away have been replaced. The east dike at the head of the pass has also been washed away. This was a training dike 1,250 feet long, and has never been replaced.

There is also an open and exposed gap 1,100 feet long between the end of the Pass a Loutre mattress sill and the end of the bank or dike on the east side of the pass. This gap was, when the work was completed, filled with a training dike. Five hundred feet of the mattress sill in Southwest Pass has also been carried away. In short, neither

the jetties nor the training dikes nor mattress sills have been kept up to the condition they were in 1879, but have been allowed to diminish and deteriorate.

Up to 1889 the channel was maintained at the required depth substantially without dredging. Since that time it has deteriorated and has not been maintained without considerable dredging. During the year ending June 30, 1896, there were one hundred and sixty-nine days of dredging. Within the last four years there has been an average of one hundred days dredging each year. The channel was not kept at the required depth for forty-seven days during the year 1897. On the whole, it appears that, although the jetties have accomplished much good and great results, they have not wholly succeeded, owing to the causes enumerated, in maintaining the fine channel that existed from 1879 to 1889. To maintain the good results then obtained the dikes, sills, and jetties carried away should be replaced or restored as far as practicable. Besides, the jetties should be extended seaward farther than originally built in order to keep pace with extension of the bar into the Gulf.

Jetties are the artificial extensions of the natural banks of the stream, and as the bed of the stream is, from the silt moving in the river, prolonged into the Gulf, the jetties must, of necessity, keep pace with such extension. For practical purposes the pass is not adequate for vessels drawing over 24, or at most 25, feet of water. This is insufficient for the wants of modern commerce. Vessels drawing from 27 to 30 feet and over are now quite common and much more economical than small vessels. It is very doubtful whether a channel sufficient for this larger class of vessels can be obtained in the South Pass. Major Quinn maintains that it can. Engineer Donovan, with a twenty-year acquaintance with the pass, maintains that it can not.

Your committee visited the pass in February last, and, with a 26-foot channel, found the pass bank full at all points. Unless the pass can absorb much more water the scouring process can not be increased nor a deeper channel obtained by that method. To secure a greater volume of water it would be necessary to build and prolong great training dikes at the head of the pass and to fortify them with mattress sills and other works, so as to bring about a larger inflow. In the next place, it would be necessary to build strong and extensive levees on both sides of the pass from the head to the jetties. There is scarcely sufficient foundation for such levees. The earth and riprapping would have to be brought from a great distance, and the embankment would be subject, more or less, to the storms, the waves, and the back wash of the Gulf. In short, such leveeing would be an extensive and most expensive jettying from the head of the pass to deep water in the Gulf. These are some of the difficulties which occur even to the lay mind. To say the least, the cost would be enormous and the result very problematical.

But the commerce of the Mississippi Valley asks and is entitled to a much deeper and broader channel to the sea than that now afforded or likely to be afforded by the South Pass. The Southwest Pass is regarded in many quarters—lay and expert—as the cheapest and most feasible route through which to obtain the requisite deep-water navigation. Congress has already made provision for a thorough examination and survey of this route. The engineers having the work in charge have not yet made their report, and until they do it would be premature for us to suggest or advise. We may add that to improve the Southwest Pass and at the same time to maintain and utilize the South Pass, thus securing the advantages of two passes, is no novelty.

This plan was adopted in 1856, when provision was made and work carried on for the improvement of both the Southwest Pass and Pass a Loutre. In case of extensive repairs or accidents there would always be one pass open and available for navigation. (See Major Quinn, Test., 443–463; Engineer Donovan, Test., 466–482; Engineer Ockerson, Test., 463–465; also his article on "The problem of deep-water navigation through the passes," etc.; also Test., 440–443, 483–490, 493–503.)

MISSOURI RIVER AND MISSOURI RIVER COMMISSION.

In respect to the Missouri River Commission and its work we beg leave to state that it has had charge of the river from Sioux City to its mouth, and that its work in recent years has been chiefly confined to the improvement of the navigability of some 45 or 46 miles of the lower reach of the river and to so-called harbor improvements for the protection of the river fronts of towns from the inroads of the river on the other reaches of the river. The work done has no doubt been beneficial for the purposes intended, and the money appropriated has, under the limitations stated, been judiciously expended.

The Missouri River is so eccentric and uncertain that great difficulties are encountered in controlling its movements from year to year, and nothing but systematic and patient effort can avail in its improvement. The commission has recommended in all its reports the improvement of the river by reaches, commencing at the mouth; and the work done under this system has proved eminently successful, but Congress has unfortunately permitted the appropriations for the general improvement of the river to be diverted to local improvements, which, being isolated and unsupported, are usually swept away by the annual overflows.

The condition of the river, by reason of the failure to adopt systematic and continuous improvement by reaches, as recommended by the commission, has been so bad as to discourage navigation, the rates of insurance upon boats and cargoes being absolutely prohibitory.

Your committee is of opinion that in view of the great agricultural wealth of the country through which the Missouri River flows, and especially the enormous production of grain, the river should be so improved as to afford every facility for its navigation by boats and barges, so as to prevent excessive charges by railroads, and also to make lower rates for transportation. If the system recommended by the commission could be faithfully adhered to for a few years, the river would be put in such condition as would induce the presence of steamboats and barges, so as to render it impossible for railroads to monopolize freights.

MISSISSIPPI RIVER FLOODS.

TESTIMONY

TAKEN BEFORE

Subcommittee of Senate Committee on Commerce,

PURSUANT TO

SENATE RESOLUTION NO. 76, FIFTY-FIFTH CONGRESS, FIRST SESSION.

MISSISSIPPI RIVER FLOODS.

ON MISSISSIPPI RIVER, ABOVE COHASSET, MINN.,
October 22, 1897.

CHARLES A. PILLSBURY, having been sworn, testified as follows:

Examined by Mr. NELSON:

Q. Your full name is what?—A. Charles A. Pillsbury.

Q. Where do you live?—A. Minneapolis.

Q. How long have you lived there?—A. Nearly thirty years.

Q. What is your business?—A. Miller. Manager for flouring mills. I am also interested in the water-power companies.

Q. Are you acquainted with the flow of water in the Mississippi River?—A. I am. Because of my connection with the water-power companies, I am accustomed to have reports made to me very frequently of the amount of water running in the river.

Q. Will you describe, as far as you know, the condition of the Mississippi with reference to flowage, overflows, and floods, before the construction of the reservoirs and since.—A. Before the construction of the reservoirs we had a much higher stage of water in the spring when the snow melted and the rains fell, and a much lower stage of water in the summer and latter part of the season, than we now have.

Q. You have for years past been familiar with the stages of water in the river from Minneapolis up?—A. For nearly thirty years. I have been interested in flour mills which derive their power from the use of the water, and the stage of the water is a matter we are deeply interested in.

Q. Would any portions of Minneapolis or the country above or below there be overflowed in the spring prior to the construction of the reservoirs?—A. There is quite a tract of what we call flats at Minneapolis below the falls, on both sides of the river, and there are quite a lot of houses there; the same is true at St. Paul to a larger extent. When the river is high these flats are overflowed and the people driven out of their houses and homes.

Q. There is a large portion of West St. Paul in that condition, is there not?—A. There is quite a large portion of West St. Paul in that condition.

Q. That is, subject to overflow?—A. Subject to overflow from the extreme high water.

Q. The construction of the reservoirs was begun in 1882 or 1883, was it not?—A. About that time, as nearly as I can remember.

Q. And the two earlier ones were completed when?—A. In 1884 or 1885, as nearly as I can remember.

Q. Those are at Leech Lake and Winnibigoshish?—A. At Leech Lake and Winnibigoshish.

Q. And the next was the one at Pokegama?—A. Yes.

Q. What has been the effect of the construction and operation of those reservoirs upon the stages of water in the river?—A. The effect has been largely to equalize the flow of water through the year, instead of having very high water during the freshets and extremely low water at other times of the year. Sometimes for half of the open season nearly one-half the water going by us was from reservoirs, and, of course, by so much was the freshet diminished in the spring; and more than that, because more or less of this water that is held back is evaporated. The evaporation in the summer is more, as you widen out the lakes by the reservoirs..

Q. Then, according to your opinion, these reservoirs prevent the spring overflows you were accustomed to have before the reservoirs were built?—A. They do not absolutely prevent them, but they greatly diminish them.

Q. And what is the effect upon navigation later in the season?—A. Of course navigation on the upper Mississippi above Minneapolis is largely logging interests. Without these reservoirs I would not have been surprised if every log had gone out this spring, the water was so high; they just barely saved them. If we had been getting the natural flow of water from up here I rather think the whole river would have been cleaned out of logs. Some 500,000,000 feet of logs, which ordinarily are sawed at Minneapolis, and a great many more at other places on the river would have been carried over below the falls.

Q. Clear down the river?—A. Clear down the river. Ordinarily there is a large portion of the season when we couldn't float logs at all if it were not for the reservoirs of water. That has not been the case this year, because the water has been at an unusually good stage; and it so happens that just about the stage of water which they need for navigation below St. Paul is a very comfortable stage for the navigation of logs above. I understand logs have been declared to be navigation. Now, there are 700,000,000 feet of logs come down every year. If you should put that on board vessels it would mean something in the shape of navigation.

Q. What effect do these reservoirs have upon steamboat navigation below the falls?—A. They keep up the stage of water so boats can come to St. Paul ordinarily until it freezes up. The boats couldn't come up there for quite a part of the season if it were not for the reservoirs of water.

Q. They couldn't come up there?—A. Not so much.

Q. Are you familiar with that part of the stream between Aitkin and Grand Rapids?—A. I am not, except from hearsay.

Q. What, in your opinion, is the effect of these reservoirs upon the stages of water below the falls?—A. It diminishes the amount of water during flood times, when it is held back in the reservoirs, and increases the stage of water during the time of naturally low water. That has been absolutely demonstrated. We get notice when the reservoirs are opened, and we notice, in so many days, a very material increase in the volume of water. It doubles it up at Minneapolis.

Examined by Mr. BERRY:

Q. I understand you to say, Mr. Pillsbury, that in the dry season the reservoirs enable boats to come to St. Paul which could not otherwise come there?—A. Yes, sir.

Q. I take it as a matter of course that the fact that boats do run there has a tendency to diminish the freight rates on the railroads.—A. We consider the presence of the Mississippi River and the fact that it is kept n a navigable condition the great regulator of railroad rates; that the

benefits should not be measured by the tonnage as much as by the possibility of sending the freight by water.

Q. And when water is let out of the reservoirs there is no question but what there is a perceptible increase in the amount of water so far down as Minneapolis and St. Paul?—A. It very often doubles the water. One-half the water that is going by Minneapolis and St. Paul to-day is reservoir water—without which the boats that now come up to St. Paul could not get there.

Q. Now, I want to ask you if the reservoirs do not diminish the water in times of flood in the same proportion that they increase it so perceptibly in the dry season?—A. No, sir; not in the same proportion, because in floods the water goes to extremes, you know.

Q. Can you tell me how far down the reservoirs here would tend to lessen the amount of water or to lower the river?—A. Well, of course, it must affect it its whole length, but the Mississippi is a very large river, and the farther down you go the less the effect would be perceptible. It must affect it clear to New Orleans, and on the theory that sometimes the last drop causes damage they might often save the serious results below.

Q. With the amount of water usually kept in the reservoirs, if the gates were opened about how long would the water flow before it would be down to normal condition?—A. They usually calculate it would take three to four months to get the water out of the reservoirs.

Mr. NELSON. To run them out?

The WITNESS. To run them out; yes, sir.

Q. About what is the distance to Minneapolis, from the upper reservoir, by the river?—A. I never figured it out; I should say about 250 miles, by the way the river runs.

Q. There is a large amount of lumber that comes down from that region to Minneapolis, is there not?—A. There are between 400,000,000 and 500,000,000 feet of logs sawed in Minneapolis annually. I think there are fully 100,000,000 feet that go over the falls at Minneapolis to be sawed by men down the Mississippi River—all the way down. Then there are, I should say, more than 100,000,000 feet sawed on the Mississippi River above Minneapolis. The practical operation of this business would be very often impossible if it were not for the regulation of the water by the reservoirs.

Examined by Mr. GALLINGER:

Q. Have any serious overflows occurred in the vicinity of St. Paul or Minneapolis since the reservoir system was adopted?—A. Yes; we have had quite as serious floods as we used to have. We had unusually high water this last spring, but that was owing to a very excessive rainfall and the large amount of snow on the ground—two or three times as much as usual; but during that time we were getting no waters from above Pokegama at all.

Q. To what extent, in your judgment, does the reservoir system affect the interests of commerce?—A. Do you mean in dollars and cents, or what?

Q. No; but how extensively are the interests of commerce affected, in your opinion?—A. Very largely; greatly. I don't know exactly the point you want to get at.

Q. Well, take the logging interest of itself.—A. The logging interests and the amount of flour shipped out of Minneapolis are something enormous. They ship over 13,000,000 barrels of flour a year. A great deal of this would go by the Mississippi River unless the railroads maintained the cheapest rates known in this country, almost.

Mr. NELSON. And the Mississippi being there keeps the rates down?

A. The fact of the Mississippi being there prevents them from making any combination to maintain excessive rates.

Mr. GALLINGER. I understand you to say, Mr. Pillsbury, that without the reservoir system navigation to St. Paul would be difficult, if not impossible, at certain seasons of the year. Is that correct?

A. Yes, sir.

Q. What proportion of freight, so far as you can determine off hand, is carried by steamer from St. Paul, as compared with that carried by rail?—A. A very small proportion.

Q. Do you freight any of your wheat or flour by steamer?—A. Yes.

Q. How large a proportion of it?—A. Not over 1 per cent.

Q. I have heard suggested that it is contemplated to very largely extend this reservoir system; that while there are now five reservoirs, either completed or in process of completion, it is suggested that it may be desirable to increase the number to (I think) forty. What is your judgment as to the desirability or necessity of largely increasing this reservoir system?—A. My judgment is that it ought to be increased as far as practicable—as far as the benefits received are properly commensurate with the cost. I am quite familiar with the country about Gull Lake. I understand a dam could be put in at Gull Lake, another one at the head of the Crow Wing, and a small canal being built between them would fill the Gull Lake Reservoir and nearly double the capacity of the reservoirs to supply water during low water.

Q. If the present system gives sufficient power to run the mills at Minneapolis, and in dry seasons enough water to float vessels to St. Paul, what benefit would be derived from a large increase of the system?—A. The vessels that come up to St. Paul are very small compared with the vessels on the Lower Mississippi, and with proper stages of water they could increase the size of the vessels, and increased size of vessels means cheaper transportation, because the larger the vessel is the cheaper they can afford to carry freight.

Q. That is not a very urgent necessity, is it, in view of the fact that so small an amount of freight is carried by steamers?—A. The necessity is not so much the amount that is carried by steamers as the amount that can be carried.

Q. Is it not a fact that the constant tendency is toward the transportation of freight by rail rather than by water?—A. The tendency is in that direction.

Q. I take it, Mr. Pillsbury, that that is due to the fact that business men nowadays can not afford to wait to have their freight transported, as they did in the days of the stagecoach—you are in a hurry.—A. No, I don't think time is verv much of an object in most of this bulky freight that is moving both ways. A very slight difference in rates will cover a good deal of delay.

Q. Approximately what is the relative cost of transporting freight from your city by rail and by river?—A. During the season of open navigation the railroads can not compete when you take the Great Lakes into account, if you mean that. If you mean all water communication, they absolutely can't compete—don't.

Q. Then why don't you send a large proportion of your freight by water?—A. We do. I thought you referred to the Mississippi River when I gave you that percentage. Including the Great Lakes, we send 95 per cent of our flour by water communication during the season of open navigation—that is, to go east. Of course there are a good many local points throughout the country where we have to ship by rail

because the water communication doesn't reach them. But during the season of navigation 95 per cent of everything that goes east of Buffalo goes by water part of the way in the flour business and wheat.

Q. How is it as between your city and points in the South where there is both rail and water communication?—A. We send a large proportion of it by river. Where it is going directly to points on the river, it almost invariably goes by river; but if it goes to points in the South which are away from the river, the local rail rates from the river to those points are generally so high that it is as cheap to ship it by all-rail routes.

Examined by Mr. NELSON:

Q. As I understand you, the cause of the high water this last year was the excessive amount of snowfall and rainfall?—A. Yes, sir.

Q. That caused the great floods?—A. That caused the great floods.

Q. And but for these reservoirs it would have caused a great deal of damage down the river, both at St. Paul and Minneapolis?—A. Well, a great lot of the logs went out at Minneapolis, and I understand if the water had gone more than a foot higher they all would have gone and the river would have been practically clean.

Q. All those logs would have gone down the river?—A. All those logs would have gone down the river; yes.

Q. And the river would have flooded the flats, would it not—the Bohemian flats and the flats in West St. Paul?—A. Yes, sir.

Q. Those flats were covered with houses and buildings?—A. Yes, sir. It would have flooded them a good deal worse than they were flooded.

Q. About how many people living on the flats at Minneapolis would have been flooded by it?—A. I should think there are on the flats, on both sides, 150 families.

Q. And in St. Paul a great many more?—A. Yes; I should think there must be at least 500 there.

Q. Families?—A. Families; yes, sir.

Q. Do you believe that these floods, or this excessively high water, are the result of the destruction of timber at the head waters of the Mississippi? In other words, has the cutting of the timber, that has been going on at the head waters of the Mississippi, had any perceptible effect in increasing the overflow?—A. I don't think it has, very much, for the reason that the pine constituted a very small portion of the entire amount of timber at the head waters of the Mississippi as compared with other kinds of trees which are not being cut; and where they cut the pine it soon grows up to hard wood, and I shouldn't be surprised if there were as many trees standing in Minnesota at the upper waters of the Mississippi to day as when they first began to cut pine.

Q. Then, in your opinion, these floods that we had this year and former years are not the result, in any degree, of the cutting of the timber at the head waters of the Mississippi?—A. No; I doubt if that has affected them to any appreciable degree.

Q. I will read a portion of this resolution, so you may see what I am aiming at and understand what I wish you to cover [reading]:

Second. If such floods are the result, to any extent, of the destruction of timber upon or near the head waters of said river or its tributaries, what measures should be adopted to prevent such destruction, and whether reservoirs to hold the water caused by rain or the rapid melting of snow on or near said head waters should be constructed to prevent the floods caused by the sudden precipitation of the rain or snow water into the streams flowing from the regions where the sources of the Mississippi and its tributaries are located?

Your opinion, then, is that the cutting of timber has had no effect at all?—A. Very slight, if any; and I am more confirmed in that opinion by a trip recently taken, seeing the immense amount of hard wood that is standing as compared with the amount of pine in regions where the pine has not been removed at all.

Q. And you think the cutting and removal of the pine now around the head waters would not have any material effect on that matter?—A. Would have no material effect, because it grows up very fast to a hardwood growth, which holds the waters back probably better than the original growth of the pine.

ARCHIBALD JOHNSON, having been sworn, testified as follows:

Examined by Mr. NELSON:

Q. Where do you live, Mr. Johnson?—A. St. Paul, Minn.

Q. In what business are you engaged?—A. Civil engineering.

Q. For whom do you work?—A. I am working for the engineer of this district of the public works of the United States.

Q. You are working for the Government engineer on the Mississippi River above St. Paul?—A. Yes, sir.

Q. How long have you been engaged in that work?—A. With the Government for the last fifteen consecutive years.

Q. Did you have anything to do with the construction of these reservoirs?—A. I was in local charge of the construction of the Pokegama, Sandy Lake, and Pine River dams.

Q. All but the Leech Lake and the Winnibigoshish?—A. All but the Leech Lake and the Winnibigoshish. The season of 1884 I was in charge, also, of the Winnibigoshish; that is, superintendent more than anything else.

Q. What effect have the construction of these reservoirs had upon the stages of water in the Mississippi?—A. The effect has been to equalize the flow of the water from the precipitation and use it in the interests of navigation as much as possible.

Q. These reservoirs, then, have held back the surplus water in the spring and reserved it for the dry season in summer?—A. Yes, sir; until their limit of capacity or of safety has been reached.

Q. In your opinion would the floods have been much greater down the river in the spring if these reservoirs had not been built?—A. Yes, sir; and especially so in 1888, which was a flood year, and also this year. If the water had not been held back at our dams the flood in the region of St. Paul and Minneapolis would have been probably 10 per cent more.

Q. At high water?—A. Yes, sir; during the flood stages.

Q. What effect has the letting out of the water during the dry season had on the river below in reference to navigation?—A. The effect has been to increase the stage in the Mississippi from Pokegama Falls to Minneapolis probably about 2 feet for a period of ninety days.

Q. And how below the falls?—A. And from Minneapolis down as far as the mouth of the St. Croix the average result from the discharge from the reservoirs has beeen from 12 to 18 inches rise for ninety or one hundred days.

Q. And from there on to Lake Pepin?—A. From there on we have had no observations, but of course the rise gradually diminishes as the river widens. We have had no observations down in that region.

Q. In your opinion, did these reservoirs have any material effect or any influence in repressing the floods last spring on the lower river

farther down?—A. Yes, sir; as I understand it, the heavy snowfall was confined to northern Minnesota and probably northern Wisconsin, and there was a very large percentage of the water from the snowfall retained. The 20th of March there was about 7 inches of water in the snow, and most of that was held; that is, in the region of the reservoirs.

Q. You are acquainted with the flats in Minneapolis and St. Paul that are settled?—A. Yes, sir.

Q. They have frequently been subject to overflows, have they not?—A. Yes, sir.

Q. Have these reservoirs had any effect in restraining the overflow of those portions of the two cities?—A. The reservoirs have assisted considerably, but the rise in the river from what was held back probably would not exceed more than 10 per cent, because the area of the watershed of the reservoirs is only about 12 per cent of the entire watershed above St. Paul.

Q. Could you give us approximately the amount of water these reservoirs hold back over and above what would be held back without them? In other words, what is the capacity of these reservoirs to hold back water over and above the natural outflow?—A. They have a capacity of about 90,000,000,000 cubic feet above the low-water stage.

Q. That is in excess of what would be held back in a state of nature?—A. That is above the low-water stage above the reservoirs.

Q. What effect, if any, has the cutting of timber around these upper waters of the Mississippi had upon these floods?—A. The effect of the cutting of timber in the timber region along the Mississippi is not appreciable, because the percentage of the area cut is very small; and, besides, when timber is removed a new growth of timber comes up immediately. After pine is cut the land is not followed up and cultivated; consequently we have a new growth of timber, which consists usually of poplar and birch.

Q. That is really better for holding back water than the pine, is it not—the leaves, etc.?—A. I don't know as to that. I don't know as there is any difference. A growth of timber, no matter what it is, by shading the ground decreases evaporation. I don't know as to the relative amount of water which is taken up in the growth of different kinds of timber. I don't know as there is any material difference.

Q. What I was aiming at is this, that the ground would retain more moisture if it was covered with a great many leaves from these trees that have leaves than if covered with these needles from the needle trees, as I call them.—A. Well, I think it is more in the shading of the ground, keeping it in the shade. I don't think there is any difference.

Q. You don't think, then, that the cutting of the timber at these head waters has had any effect, appreciably, upon the matter of floods?—A. Not from the amount that has been cut.

Q. Do you think that the continued cutting of the pine, at the rate it has been going on, would have any material bearing?—A. Not so long as the ground is not followed up by cultivation.

Examined by Mr. BERRY:

Q. How many of these reservoirs are there altogether, Captain?—A. There are five.

Q. What is the distance by river from St. Paul to the farthest of these reservoirs at Lake Winnibigoshish?—A. That is largely guesswork. The Winnibigoshish Reservoir is probably about 380 miles from St. Paul by river.

Q. And the next farthest is the Leech Lake Reservoir?—A. The Leech Lake Reservoir is about the same distance by river. The Pokegama Reservoir is about 300 miles from St. Paul; Sandy Lake, 200 miles, and Pine River dam about 150 miles. I may be a little wild on these figures.

Q. I wanted them approximately; that is all. Do you think that in this region above Minneapolis and St. Paul additional reservoirs could be built which would in the same proportion, or in any proportion, tend to increase the stage of water in the river below St. Paul during the low stage of water? You have stated that it increased it a certain per cent now from St. Paul down to the mouth of the St. Croix. Is it probable that if others were built it would further increase that flood tide in low-water time and restrain it in the same proportion that these others have?—A. Do you have reference now to the system in Minnesota, or Minnesota and Wisconsin both?

Q. I have reference to Minnesota. You have five reservoirs here?—A. Yes, sir.

Q. Now, I want to know, if additional ones were built, whether the flood tide could be increased in the same proportion, or any proportion, at a low stage of water in the river below St. Paul?—A. By increasing the number of dams from now on the effect will not be nearly as great, because the best holding grounds have been closed in. There are two or three others which would help very materially, but not at all in the same proportion as those which have already been dammed up.

Q. I am requested to ask you about Gull Lake and the head of the Crow Wing.—A. If the Crow Wing River is dammed up and a 14-foot dam put in Gull Lake, we would get there about 14,000,000,000 cubic feet. We have already about ninety; that would be about 12 per cent more. But if the Crow Wing River is not dammed and its waters turned into Gull Lake, the reservoir at Gull Lake would give about 6,000,000,000 to 8,000,000,000 cubic feet in place of 14,000,000,000. Mille Lacs is another large water area, but its watershed is so small that it has been a question all along as to whether it would pay to build a dam there. The conclusion arrived at was that it would not pay, although there is a good holding ground there. At the headwaters of the Crow Wing River there is a nest of lakes; a reservoir could be created there and a certain amount of water gathered up, though as to the amount I couldn't say.

Q. That is in addition to the 14,000,000,000 you speak of at Gull Lake?—A. In addition to Gull Lake.

Q. What effect, if any, have these reservoirs had upon the commerce of the upper river? Have they tended to facilitate the transportation of logs and lumber, and have they been a benefit in that respect?—A. The effect of the reservoir system is, of course, most noticeable near the dams, because the river is narrower there and the rise is more; and everything that has been floating on the river—commerce—has been greatly benefited, no matter what it has been, whether logs or steamboats or anything else of that kind. The river in its natural condition, at certain times of the year, could not float anything, hardly a boat drawing 12 inches of water at times; and it has been a benefit to navigation of all kinds, from the dams down as far as we have observed—that is, as far as the mouth of the St. Croix. The office has been informed, at times, of a noticeable rise as far as Dubuque, but that is from hearsay; we have had no observations of our own.

Q. Since the reservoirs have been built, the lumber and the logs can be floated out of that region at any time at the lowest tide of the water, can they not?—A. Yes, sir.

Examined by Mr. GALLINGER:

Q. Captain, at the present time these reservoirs have a capacity of 93,000,000,000 feet, and the cost has been, in round figures, about $1,000,000, including the appropriation to the Indians. It appears from this memorandum (Exhibit A) that you can get 14,000,000,000 feet at Gull Lake.—A. That is by damming the Crow Wing River.

Q. By means of the high and low reservoirs there, in addition to the present capacity of the reservoirs (a little over one-seventh of what you now get), at a cost of $1,285,000, or a larger amount would have to be expended at that point to get 14,000,000,000 feet than has been expended on these other reservoirs to get 93,000,000,000 feet. Now, would you think that a judicious appropriation for the Government to make?—A. Not for the high dam; no, sir; I would not. I don't think the country would get the worth of the money.

Mr. NELSON. But the low dam would be all right?

The WITNESS. Yes, sir.

Mr. GALLINGER. This memorandum (Exhibit A) shows that the low dam would give a capacity of 2,712,000,000 feet, at an approximate cost of $85,000. You think that would be a judicious investment of money?

A. Yes, sir.

Q. Am I correct in the assumption, Captain, that your judgment is that cutting the timber has not materially affected the stage of water at the headwaters of the Mississippi?—A. It has not yet; no. sir.

Mr. NELSON. Is there anything you think of that you would like to tell us bearing on this matter?

The WITNESS. I don't know whether it came in the printed list of questions or not, but I will say that people along the river below, particularly in Aitkin County, have been claiming that they are being damaged by the reservoir system. I will say that the reservoirs have never been operated to their disadvantage; that if the reservoirs hadn't been in, their case would have been worse than it has been. The reservoirs have assisted them; although complaints are being made by people along the river that they are flooded out by the reservoirs, it is not so.

Examined by Mr. BERRY:

Q. In what way do they claim the reservoirs tend to increase the floods?—A. They claim that we accumulate water and let it off in flood stages; that we let it accumulate and let it off in an undue proportion. Well, we don't do anything of the kind.

Q. And you have never let it off in a time of high water, at a time or in a way that would have increased the flood tide in Aitkin County over what it would have been if there had been no reservoirs there?—A. We have always diminished the flow by holding the water back.

Mr. NELSON. In high water?

The WITNESS. In flood stages. During the low-water season we do overflow bottom lands below Pokegama Falls; they are being overflowed by reason of the operation of the reservoirs, when, if the reservoirs were not in, those lands would not be flooded.

Mr. NELSON. That is above Pokegama Falls?

The WITNESS. Below Pokegama Falls for about 10 miles.

Q. Is that of lands that are in cultivation?—A. The lands are used simply for meadows. They are meadow lands. That is only for 10 miles below Pokegama Falls. That is as far as the bottom lands are being overflowed by the fall discharge.

Q. Well, does that damage those people there?—A. Yes, sir.

Mr. GALLINGER. Have damages been paid by the Government in any case, Captain, so far as you know?

The WITNESS. Damages have not been settled completely except in two cases; but that matter was taken up a short time ago and an understanding has been arrived at with some other parties as to a settlement. The question was taken up in 1890, I believe, and after awhile proceedings were commenced to condemn those lands, but the proceedings were abandoned and nothing has been completely settled up, with the exceptions I stated; but I expect there will be before long, as it is underway by the Department.

Q. To what extent did that overflow extend on each side of the river for a distance of about 10 miles below?—A. It floods the entire bottom lands, the lowlands.

Mr. NELSON. How wide are the bottom lands there?

The WITNESS. They are usually not more than 400 or 500 feet in width. The acreage is small. The main damage has been due to running the hay out. We begin to let the water off about the 1st of August, and hay is not ripe then sometimes, and the hay is injured in that way; and then leaving the water on for so long—for ninety days—in the fall, the hay has a tendency to run out. And another thing, while those people have always been notified when the discharge is to take place, they are sometimes compelled to cut their hay before they would like to—that is, they must shape their affairs to what is to take place.

Q. About how many people own land within that 10-mile strip—about how many people does that affect adversely?—A. The number of families it affects is probably fifteen or twenty. But a portion of the town site of Grand Rapids comes in this overflow, and I couldn't say the number of persons who are interested in that portion. There is no improved property on the lowlands, at Grand Rapids or La Prairie, which are overflowed; there are no complaints from them. However, if property owners should wish to build on those lands at any time, of course it would be a serious matter in regard to those lands that are within flowage.

Examined by Mr. GALLINGER:

Q. That hay, I take it, is of a cheap and inferior quality, is it not?—A. No; it is a good quality of wild hay, blue joint. No; it is a good growth.

Q. What is it worth per ton in the market after it is harvested?—A. That varies with different years. In the region of Grand Rapids hay is worth from eight to ten dollars a ton. The whole value of this land within 10 miles below Pokegama is about $15,000. An easement could be procured on some of it. Some might prefer to sell. But between what the Government can get an easement on and the portion they would have to take in fee the cost would be about $6,000 or $7,000; but if there was an absolute condemnation or a condemnation for reservoir purposes, then it would run up to about $15,000.

Q. Is there any counter advantage to these people resulting from keeping the water from their lands at other seasons of the year?—A. You mean those lands that are overflowed?

Q. Yes.—A. No, sir; there is not.

Examined by Mr. NELSON:

Q. Are you acquainted with the character of the river and its banks from Pokegama to Aitkin?—A. Yes, sir.

Q. Are there any lands down along there that are subject to over-

flow besides what you have been describing lately?—A. There are no other lands below Blackberry Brook that are being flooded by the discharge from the reservoirs; that is, by the releasing of water for navigation purposes.

Q. No other lands that are flooded at all below there?—A. No, sir.

Q. Clear down to Aitkin?—A. No, sir.

Q. Well, are there lands there that are flooded or would be flooded if the reservoirs were not there?—A. Yes, sir; nearly all the lands on the bank of the Mississippi through Aitkin County are subject to overflow during flood stages.

Q. Always have been?—A. Always have been.

Q. And the reservoirs really diminish that?—A. The reservoirs have diminished that overflow.

Q. So that really they are better off now than before the reservoirs were constructed?—A. Yes, sir.

Q. In that reach of the river?—A. And they have always admitted that up to the present year.

Q. The reason I asked is that certain parties have been making complaints in the neighborhood of Aitkin and above there. In your opinion, then, as a matter of fact, the reservoirs below this point you speak of have been of advantage to those bottom lands rather than a detriment?—A. Yes, sir.

Q. All along?—A. The lands would have been overflowed to a much greater extent if no dams were in.

Q. And they are not injured by the letting out, and are rather helped by the retaining of the water by the reservoirs?—A. Yes, sir; those are the facts of the case.

Mr. BERRY. Captain, don't you think that a well-constructed levee along that section would tend to improve the navigation of the river and aid in commerce?—A. No, sir.

Mr. NELSON. Judge Morris, you are Representative from this district. If you wish to ask any questions, please feel at liberty to do so.

Examined by Mr. MORRIS:

Q. Captain, you say the letting out of that water has never injured those people at all?—A. No; never injured those in Aitkin County.

Q. What time did you say you usually begin to let this water out?—A. It is usually about the 1st of August.

Q. From that time on, I understand you, it has never injured those people, but has rather been a benefit?—A. The only parties injured are those owning bottom lands for 10 miles below Pokegama Falls.

Q. Last summer they had very heavy rains here in the latter part of June and the first part of July, didn't they?—A. The rain was heavy during June and July.

Q. At that time the reservoirs above here—these reservoirs high up the river—were full of water, were they not?—A. Well, nearly full.

Q. And did they not have to be opened at that time, in June and July?—A. The three reservoirs here—Pokegama, Winnibigoshish, and Leech Lake—of course, are controlled by the Pokegama Falls Dam, and the discharge from Pokegama Falls Dam was just a very little more than enough to overflow the bottom lands for the first 10 miles below Pokegama Falls.

Q. Well, isn't it a fact that you did last summer, in June and July, have to open the gates at the dams on account of the heavy floods and the reservoirs having been so full of water from the large amount of snow that spring?—A. Yes, sir.

Q. Now, that is the fact, is it?—A. Yes; that is the fact, but the fact also is that if the dams were not in the discharge would be much more.

Q. Well, that would be the case all along the river, wouldn't it?—A. Well, we are the only ones who have any dams.

Q. Well, it would be the case clear down to St. Paul. If the dams were not in, it would be very much greater, would it not?—A. Well, the dams were all open below Pokegama Falls, and the lumbermen's dams were open.

Q. But isn't it a fact that the water went out of these dams in June and July last year?—A. Do you mean out of the reservoir dams?

Q. Yes.—A. Well, we released a portion. The Pokegama Dam was full, and what was coming in we had to let go.

Q. And would that flood have been as great if that water hadn't been let out?—A. Do you mean if we had held it entirely?

Q. If you had held it entirely back?—A. Certainly the flood would have been reduced if we had held back the water entirely.

Q. Now, Captain, you say you know that territory about Aitkin?—A. Yes, sir.

Q. There are a large number of farmers in there now, are there not?—A. There are farmers along the river most of the way down from Sandy Lake.

Q. Now, are you sufficiently informed to know whether we might in the region just above Aitkin, between Grand Rapids and Aitkin, increase this reservoir system to any extent?—A. I don't think there is sufficient holding ground anywhere on the tributaries to appreciably affect the floods.

Q. How about Willow River and the Prairie River?—A. I don't think there is any holding ground on Willow River that is worth inclosing; neither is there on Prairie River; that is, if what holding ground there is along Prairie River was inclosed I don't think it would appreciably affect the floods. It is true those bottoms would be filled, but the reservoirs are so small that it wouldn't be appreciable.

Q. The river is very crooked there, isn't it, Captain?—A. At Aitkin?

Q. Yes; just above and below Aitkin.—A. Yes, sir; it is a crooked river.

Q. Could that flooding be decreased at all by in any way straightening the river?—A. Yes; you would increase the current by cutting long channels.

Q. Well, couldn't you cut off bends there across the loop of which is a very narrow distance?—A. Yes, sir; there are some bends a mile and a half, some others 2 miles, some 3 miles in extent, and straightening them would materially increase the velocity.

Q. And if you did that you would improve the river below, at Minneapolis and St. Paul, to some extent, wouldn't you?—A. Below St. Paul and Minneapolis?

Q. Up to St. Paul and Minneapolis.—A. I don't think it would be appreciable.

Q. By letting the water go down faster?—A. I don't think it would be appreciable.

Q. If the present reservoirs at Winnibigoshish and Leech Lake were strengthened and repaired so as to hold their full capacity would they be able to hold back the water or, nearly all the water, with a flood equally high to that which you had last June and July?—A. Yes, sir; they would ordinarily, with the ordinary amount we have in the fall, and then the following year—in the spring of the year—if the reservoirs were strong enough we could have probably held all the water that

came during the flood stages at the Winnibigoshish and Leech Lake dams; but at the Pokegama dam, that was full anyway, and unless the dam was raised there would be nothing gained by increasing its stability; it is strong enough; but at the two upper dams the flood would have been appreciably diminished in Aitkin County, providing we could have held all the water back.

Q. And that can be accomplished by simply strengthening and repairing the present dam?—A. Yes, sir.

Capt. F. V. ABBOT, having been duly sworn, testified as follows:

Examined by Mr. NELSON:

Q. You are the Government engineer at present in charge of this reach of the river?—A. Yes, sir.

Q. I wish you would prepare a statement for the committee, giving a list of the reservoirs in your territory, when they were constructed, the cost of each, and the amount of water that is penned up in each reservoir over and above what would be there in a state of nature.—A. I have that very thing here. I haven't the dates, but I have the name of each reservoir; the drainage area in square miles tributary to it; the storage capacity above low-water level, in cubic feet; remarks as to whether we have been able to fill the reservoirs with the rainfall each year or not, and the year in which the work was completed. I have also given here the aggregate drainage area, and the aggregate capacity, and the cost of the whole. With reference to Gull Lake, I have given figures for the proposed storage, and the estimated cost of the low dam and of the high dam. I have given the figures of the drainage areas of the Mississippi River above St. Paul, of the Minnesota River, and of the Mississippi River above Minneapolis, and the percentages these reservoirs hold. The effect on the flood heights, due to the reservoirs, was very strongly illustrated in the flood of 1897. The high water occurred at St. Paul on April 6, at which time there was about 85,000 cubic feet per second; the reservoirs thawed out about April 1; it takes eleven days for reservoir water to reach St. Paul, consequently at the time of the height of that flood no water had come down from the reservoirs; so they didn't diminish the height of the flood at all, for in a state of nature that water would have been withheld by reason of not having thawed. They have less effect upon extreme high water (did in this last flood, at any rate) than is generally supposed, I think.

Q. In other words, the reservoirs had no effect upon the extreme height of the flood of 1897, for water could not have gotten out because it was frozen?—A. It was frozen up solid. It did not thaw until April 1, and it would take eleven days for it to get down, and the height of the flood was April 6.

Q. How long did that high flood continue?—A. I do not know, but undoubtedly they would have maintained the flood longer.

Q. Well, suppose the high water occurred at that time, would not the melting of the ice and snow and the running out of the water subsequent to that time have made a flood of longer duration?—A. It probably would have, but that is an "if" which I can not tell.

Q. Was not the general flood of the Mississippi river in 1897 remarkable in character—not that it was the highest we had ever had but that it was of longest continuance?—A. Yes, sir.

Q. And upon the question of continuance would not the reservoirs cut a great figure?—A. Undoubtedly, in this case.

Q. But unless you should go to work and ascertain the length of the flood at St. Paul, you could not tell exactly what the effect of the reservoirs was in this case?—A. Not only that, but you would have to have information which never has been obtained and can not be obtained, as to the relative discharge of the Minnesota River and other tributaries. It is really too complicated a question to answer, except that at the time the flood reached its maximum the water had not got there anyhow.

Q. Have you any data by which you can tell how long the river remained at flood stages at St. Paul?—A. Yes, sir; I can give you the gauge readings; I haven't them here; I have them in St. Paul.

Q. And you can tell how long it remained at high flood?—A. Yes, sir.

Q. May I see the statement you have here?—Yes, sir.

Witness here presented before the committee the following statement, marked Exhibit A:

EXHIBIT A.

Reservoir memorandum, October 18, 1897.

Reservoir.	Drainage area.	Capacity above natural capacity.	Remarks.	Completed.
	Sq. miles.	*Cubic feet.*		
Lake Winnibigoshish	1,442.43	45,024,000,000	Never filled	1883-84
Leech Lake	1,162.80	33,094,000,000	do	1884.
Pokegama Falls	660.23	4,700,000,000	Filled each year	1884-1889.
Pine River	562.07	7,500,000,000	Never filled	1886.
Sandy Lake	421.50	3,158,000,000	Filled each year	1895.
Total	4,249.00	93,476,000,000		

Total appropriation, $905,500.

	Cubic feet.
Capacity of proposed low reservoir at Gull Lake ($85,000)	2,712,096,000
Capacity of proposed high reservoir at Gull Lake ($1,200,000)	11,898,128,500

	Square miles.
Drainage area of Mississippi River above St. Paul	36,081
Drainage area of Minnesota River	16,350
Drainage area of Mississippi River above Minneapolis	19,731

Drainage area of the five completed reservoirs=21¼ per cent of entire drainage area above St. Paul.

Drainage area of the five completed reservoirs=21¼ per cent of entire drainage area above Minneapolis.

High water at St. Paul in 1897 occurred on April 6 (85,000 cubic feet).

Reservoirs thawed out about April 1.

In regard to the release of water from the Pokegama Falls Dam, the following discharge during each month will probably give the most satisfactory results during each year:

Discharge per second in—	Cubic feet.
January	300
February	300
March	100
April	500
May	900
June	900
July	950
August	2,250
September	2,250
October	2,250
November	943
December	300

For the discharge at Pine River Dam the following arrangement will probably cover the case to the best advantage:

Discharge per second in—	Cubic feet.
January	25
February	25
May	123
June	250
July	325
August	450
September	450
October	450
November	20
December	25

Q. Are the figures stated in Exhibit A true to the best of your judgment and belief?—A. To the best of my knowledge and belief they are true.

Q. I wish you would supplement that exhibit, Captain, with a statement showing the cost of each reservoir. Now, you have given the storage capacity here; that is the total?—A. No, sir; that is above the ordinary low-water level in the reservoir.

Q. Oh, that is above what it would be in a state of nature?—A. Yes, sir.

Q. Then there is nothing to supplement, except giving the cost of each reservoir.—A. That and this statement for the future, which I think should be included: that we have now utilized all the really admirably adapted sites; that we have secured a storage of about 93,000,000,000 cubic feet for about $905,000; that the next most available site which has been investigated would cost about $1,200,000.

Q. That is the high-water dam at Gull Lake?—A. Yes; to increase the storage about one-ninth more than it is at present. In other words, to store water in the future, in addition to what we have, will be nearly nine times as expensive as in the past, and that comes from the fact that we have not the storage areas; we have not the sites adapted for holding the water. We have already occupied the best sites, in other words.

Q. I wish you would make a statement giving the distance from Minneapolis to each reservoir and the distance between the reservoirs; for instance, take the lower reservoir, Pine River—state how many miles it is from Minneapolis, and describe its location, and the same as to Sandy Lake and each of the other reservoirs, and state the cost of each and how much water they pen up. Then make a summary statement showing the relation that these reservoirs have one to another and the distance between them, the cost of each of them, the storage capacity, the time it would take for the flood water to reach Minneapolis, and in addition to that state the duration of the last flood at Minneapolis, as it appears from your gauges, and give any other facts you can bearing upon the questions under consideration.—A. Yes, sir. The upper two reservoirs, Winnibigoshish and Leech Lake, now have such capacity that we have never been able to fill them with any year's rain. It is possible that in 1897 they might have been filled if the dams had been in such condition as to safely hold all the water for which they were designed. The timber sluiceways at both Leech Lake and Winnibigoshish were, however, in such need of repairs that it would have been unsafe to have retained the full quantity of water they were designed to store, consequently no effort was made to store all the water that fell. Only as much was released during the high-water season as

was necessary to keep the water in the reservoirs from rising above t level at which the sluiceways were safe.

In further answer to the last question the witness submitted t following statement and sketch:

Distance, Minneapolis, Minn., to—	Mil
Pine River Dam	1
Sandy Lake Dam	2
Pokegama Falls Dam	3
Lake Winnibigoshish Dam	4
Leech Lake Dam	4

The locations and relative positions of the reservoir dams are show on the copy herewith of map accompanying Colonel Jones's annu report for 1896.

Cost of each reservoir.

	Cost.
Lake Winnibigoshish (capacity, 45,000,000,000)	$216,390.1
Leech Lake (capacity, 33,000,000,000)	172,912.1
Pokegama Falls (capacity, 4,700,000,000)	85,000.0
Pine River (capacity, 7,500,000,000)	90,000.0
Sandy Lake (capacity, 3,200,000,000)	114,000.0
Total	685,302.2
Extraordinary repairs to Pine River Reservoir	13,000.0
Ordinary repairs and operating expenses (1 reservoir for fifty-two years, at $4,000)	208,000.0
Total	906,302.2

Money statement.

Total appropriations	$905,500.0
Total allotments for care and operation	72,396.7
	977,896.7
Amount available June 30, 1897	71,594.5
Total expenditures	906,302.2

The records show that a rise in the river at St. Paul commences in seven or eigh days following the release of water from the distributing reservoir at Pokegam Falls, and in about five days thereafter the full effect is felt. The mean time i therefore ten days.

The high water of 1897 commenced at St. Paul on March 20. The water gradually rose until April 6, when the stage was 18 feet above low water. By the end of April the water had fallen 8 feet, and by the end of May the river was at an ordinary summer stage. On July 5 another but smaller rise commenced, reaching its maximum, 11.8 feet above low water, on the 17th of the same month, and had fully receded by the middle of August.

The testimony, so far as the influence of the reservoirs upon high water is concerned, refers to the effect in the vicinity of St. Paul and Minneapolis. The effec of the reservoirs in controlling floods immediately below the dams is given in Mr Johnson's testimony.

ROCK ISLAND, ILL., *October 26, 1897.*

Col. W. R. KING, having been sworn, testified as follows:

Examined by Mr. NELSON:

Q. Colonel King, are you the United States engineer in charge at Rock Island?—A. Yes, sir.

Q. What part of the Mississippi River is under your charge?—A. At present from St. Paul to the mouth of the Missouri River, a distance of about 700 miles.

Q. Have you charge of any of the tributaries?—A. Yes, sir; there is

a small tributary at Galena. There is a lock and dam there; that is about all.

Q. How long have you been in charge here?—A. Since two years ago last July—a little over two years.

Q. What was the character of the high water and floods last spring here on your reach of the river?

In reply to this question witness presented to the committee the following statement, marked Exhibit B, showing the stages of high water of the Mississippi River from 1880 to 1897, inclusive, at St. Paul, Dubuque, Rock Island, Keokuk, Hannibal, Louisiana, and St. Louis.

The WITNESS. Those figures are from the official records. Some of those are kept by the Signal Service men and some by the bridge tenders.

EXHIBIT B.

High-water stages, Upper Mississippi River.

Year.	St. Paul.	Dubuque.	Rock Island.	Keokuk.	Hannibal.	Louisiana.	St. Louis.
1880	15.2	22.7	18.4	17.4	18.8	15.3	25.4
1881	19.5	21.2	17.7	18.8	20.6	18.3	33.7
1882	13.3	16.8	14.1	15.8	18.5	16.8	32.4
1883	12.2	16.7	13.2	16.7	17.0	16.7	34.8
1884	10.2	14.6	11.9	16.6	18.6	17.2	28.2
1885	7.4	12.5	10.9	14.2	13.3	12.8	27.0
1886	8.2	15.4	12.7	16.0	17.1	15.5	27.0
1887	9.6	15.0	11.5	13.3	12.0	11.3	20.5
1888	14.4	22.4	18.6	19.6	21.7	17.8	29.3
1889	4.5	7.4	6.0	9.7	8.6	9.3	24.4
1890	7.0	14.2	11.7	12.6	13.5	12.0	20.7
1891	6.4	13.9	10.3	11.0	12.2	11.3	23.7
1892	12.6	18.0	19.4	19.2	20.8	18.8	36.0
1893	14.7	16.8	13.6	14.9	16.8	16.5	31.5
1894	11.8	15.5	12.3	11.4	12.2	10.7	23.3
1895	4.6	6.3	8.9	4.8	5.3	7.0	23.3
1896	10.7	13.9	12.0	11.9	13.3	12.1	27.7
1897	17.5	17.9	15.0	18.4	20.9	18.5	22.0

Unreclaimed land subject to overflow, Upper Mississippi River (St. Paul to Missour River).

Locality.	Miles.	Approximate acres.
St. Paul to St. Croix River	30	3,800
St. Croix to Lake Pepin	29	15,400
Lake Pepin to Winona	66	27,000
Winona to La Crosse	32	32,600
La Crosse to Lansing	42	30,700
Lansing to Wisconsin River	37	19,200
Wisconsin River to Cassville	25	6,400
Cassville to Dubuque	30	11,500
Dubuque to Savanna	44	20,600
Savanna to Rock Island	63	56,700
Rock Island to New Boston	52	58,000
New Boston to Dallas	45	68,800
Dallas to Keokuk	32	21,300
Keokuk to Quincy	41	48,900
Quincy to Clarksville	60	23,000
Clarksville to Cap au Gris	36	45,400
Cap au Gris to Missouri River	50	74,900
Total		564,200

Q. I haven't looked over those figures, but you have examined them in detail and can state the general purport of them. Was not the flood last spring higher than ever before?—A. I think not.

Q. Not as high?—A. I think not.

Q. The water was less in the Mississippi River then than at some prior floods?—A. It is such a long stretch of river that sometimes the flood varies; without any apparent reason it will be higher in one place than another. It comes along in kind of a wave, and if it happens to spread out, and doesn't get any reinforcement, it may be higher at the upper part, proportionally, than it is below. There are so many tributaries that there may be high water in one part of the river and not in the rest.

Q. As a matter of fact, then, the overflow and flood in the Mississippi River, within your territory, was not as great as it had been on previous occasions?—A. That is as I understand it; yes, sir.

Q. And cause no unusual or unreasonable amount of damage anywhere?—A. No, sir; the only thing was a break in one of the levees below here.

Q. Now, will you tell us, in a general way, what has been done in the way of river improvements on the different reaches of the river from St. Paul, down? What is the nature of the Government work on the reach from St. Paul to the St. Croix?—A. It is shore protection by means of brush and stone riprapping to prevent the washing and caving of the banks, and wing dams and closing dams (principally wing dams) to narrow the channel where it is necessary to narrow it.

Q. Those wing dams are of rock, I noticed.—A. They are of both rock and brush. They are at least half of brush—sometimes more than half brush.

Q. And rock on top?—A. Rock on top. Well, there is rock all through them. They lay down a mat of brush, then weight it down and put on more brush, and so on; according to the height of the dam they increase the number of those mattresses.

Witness produced the following blue print (Exhibit C), showing the method of construction of wing dams:

Q. The work there, then, is simply to improve navigation, and not for the purpose of protecting overflowed lands?—A. There is very little overflowed land above here—very little to protect.

Q. Are there any levees on your reach of the river?—A. Yes; below Rock Island, but not above.

Q. There are no overflowed lands to protect anywhere here, then?—A. Well, they are not wide enough to pay to protect, for the high land comes in pretty close to the river and leaves only a narrow margin; but there are a great many places that overflow.

Q. But what you call the river bottoms from here up are not of sufficient width to count the overflow?—A. No, sir.

Q. Or to have any special consequence?—A. Not at present. When land gets to be much more valuable, they may be.

Q. Now state the nature of the improvements from the St. Croix down to Lake Pepin.—A. It is of the same general character.

Q. Same general character of work?—A. Yes. All the way down, for that matter, on this 700-mile reach of river, it is of pretty nearly the same character. The river is quite manageable—does not get in behind our work and destroy it.

Q. Could not Lake Pepin be made into a sort of reservoir to hold back the waters of the Upper Mississippi? Would it not be possible to raise that lake at its outlet?—A. It might be raised a little, but riparian rights would have to be considered there. The railroads are not very high above the water, you know.

Q. But a reservoir could be made there?—A. Yes, sir; there is no doubt of that.

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Q. Do you remember the length of that lake, approximately?—A. It is in the neighborhood of 25 miles in length.

Q. And the average width is about how much?—A. About 3 miles.

Q. Have you any record here of the depth of that lake?—A. We have, of its depth in places.

Q. What is the average depth of it?—A. Twenty-five to thirty feet. We are building some breakwaters there now for the protection of navigation, and had already built two.

Q. On Lake Pepin?—A. On Lake Pepin.

Q. At what points?—A. Well, this last one is at what is called Kings Coulee. The others were built a long time ago, at Lake City and at Stockholm.

Q. From Lake Pepin down to the mouth of the Black River, at La Crosse, are there any special improvements?—A. The same as I have mentioned before.

Q. Riprapping and wing dams?—A. Riprapping and wing dams.

Q. That is to narrow the river and make a better channel?—A. Yes.

Q. They are built on the principle of narrowing the river and having the channel scoured out by the force of its own water, isn't it?—A. Yes, sir.

Q. And from La Crosse to the mouth of the Wisconsin, at Prarie du Chien, is there the same kind of work?—A. The same thing; yes, sir.

Q. Does the Wisconsin River bring down much water?—A. It does at times. It is very narrow. I don't think they have attempted any navigation on it at all.

Q. No; I think not of recent years. Well, the same general character of work has been done along the river on the reach from La Crosse to Prairie du Chien?—A. Yes, sir, and clear to the mouth of the Missouri, except at Rock Island, where there has been another kind of work, and at Keokuk—the Des Moines Rapids Canal.

Q. From St. Paul down the principal tributaries that bring water into the Mississippi River are the St. Croix, the Chippewa River, the Black River, the Wisconsin, the Rock River, the Illinois River (on the east side of the Mississippi), and on the west side there seem to be none of any consequence until you get to the Des Moines River?—A. And the Salt River, a small stream.

Q. Do any of these streams I have mentioned bring in any floods or large volumes of water—anything of an unusual character?—A. Well, I don't know about that; they certainly must in the spring—in the flood season—but they are comparatively small streams. The Chippewa does. They had a big ice jam at Chippewa Falls. There is a canal at Keokuk about 8 miles long. That is one of the largest works on the river; three locks.

Q. That is on the west side?—A. Yes, sir.

Q. At the mouth of the Des Moines?—A. Yes, sir; near there.

Q. Well, there is another canal on this side, I noticed yesterday; I think near Galena Junction; not a canal, but a lock or something?—A. A lock; yes. That was built a few years ago by some people at Galena, and then they got Congress to pay for it.

Q. What was the object of that lock?—A. To get up to Galena. A man by the name of Moore told me the other day (he was the man that originated the idea) that there was a sawmill up there, and he thought by building this lock they could improve the value of it, etc.; but that has proved rather a failure. There has been no navigation at all there, hardly.

Q. You are repairing that, aren't you?—A. We are repairing the

lock, and some dredging has been done there recently, but the navigation is almost nothing.

Q. There are really, then, on your reach of the river, as I understand it, Colonel, no unusual floods taking place?—A. No, sir.

Q. And no land of any consequence, except these little marshy bottoms and timber bottoms in the river, that are overflowed?—A. Above here there is very little, but below some of the tracts are quite large. We are making surveys now with a view to protecting some there.

Q. You are acquainted with the river from Rock Island up, in a general way. Are there any places, aside from Lake Pepin, that would be suitable for reservoirs to hold back the water during freshets or high water?—A. I don't know of any, except away up at the head waters; that is not in my district.

Q. Beyond St. Paul, you mean?—A. Yes; there is nothing in my district.

Q. There would be nothing so good as Lake Pepin?—A. There may be, possibly, along some of the small tributaries, but I am not familiar enough with them to say about that. Along those little tributaries up the river there may be places that could be utilized, but I doubt it very much. The land is all taken up, and it would probably be very expensive to acquire any large areas there.

Q. There might be on the St. Croix River, at Lake St. Croix, and the Mississippi at Lake Pepin, might there not?—A. By putting in a lock at the lower end of Lake Pepin they could certainly back it up some.

Q. What could be done by the Government, if there is anything you can suggest, on your reach of the river that would aid in checking or reducing the floods of the Lower Mississippi River?—A. I am under the impression that building these levees will in a small way (I don't know to what extent) increase the floods below. If we confine the river absolutely within its channel along here, the water has got to get out that much quicker. If we let the water expand over more ground, it will be retarded; it will spread out, and it will take several days for it to fill up and the water soak into the ground, and it will be a long time soaking out again. But if we keep it in the channel and don't let it cover these areas at all, that will tend, I think, to increase the floods below.

Q. What levees have you been building? From here down, you say.—A. Where the red spaces are on the map.

Witness here produced to the committee the following map, marked Exhibit D.

Q. The Flint Creek Levee seems to be the first one. You have fenced off quite a basin there?—A. Yes.

Q. Do you remember the length of that?—A. The area is marked on the map—44,000 acres.

Q. Forty-four thousand acres there that was subject to overflow that you have, so to speak, fenced off with a levee?—A. That is right; yes, sir.

Q. And the next is the Warsaw Levee, lower down.—A. Yes, sir.

Q. And there, I see by this map, you have fenced off 60,000 acres.—A. Yes, sir.

Q. And the next is Sny Levee, and there you have fenced off 150,000 acres, I see.—A. Yes, sir; part of that is old State work. They did a little there, and we have strengthened them and made them larger.

Q. To the extent, then, that you have built those levees and confined the water in those reaches of the river within narrower channels, you have increased the volume of water in the river—A. I think so; yes, sir.

Q. That is, expedited the overflowing of the river to that extent?—A. I think so; yes, sir.

Q. And that is the effect generally, is it not, of building levees and shutting up the river within narrower limits?—A. Yes, sir; it also lowers the water during low-water stages, I think, to a certain extent. That, of course, we can't tell, but if we allowed this water to spread out and soak into the soil, over thousands of acres, it would find its way into the river again later on; so levees would naturally lower the low-water level as well as increase the floods.

Mr. BERRY. The tendency would be to make the rise and fall more rapid each?

The WITNESS. Yes, sir.

Mr. BERRY. A more rapid rise and a more rapid fall?

The WITNESS. Yes, sir.

Q. Have you had any experience on the lower reaches of the river?—A. No, sir; I have not.

Q. This is your first acquaintance with the Mississippi?—A. Yes, sir.

Q. You are familiar with hydraulic engineering?—A. I have looked into it a little, but not so much as I would have done if I had been down on the lower part of the river.

Q. Are you familiar with the character of the Missouri River and the floods along that river?—A. No; except in a general way. I was on the Missouri River Commission only a few months and only attended one meeting, and I know only in a general way the condition of things there.

Q. Do you not think that one of the main causes of the floods of the Mississippi of recent years has been the building of new levees and closing up new basins that were formerly open for the river to cover at high water?—A. I presume they have had an effect, but how great an effect I couldn't state, of course. I think very likely they have had some, but of course I couldn't say whether it has been homeopathic or has been really very marked.

Q. There are no Government levees anywhere above Rock Island?—A. No, sir.

Q. And the Government works from Rock Island up are simply confined to the improvement of navigation?—A. Yes, sir.

Q. And, in brief, may be said to consist of riprapping and wing dams?—A. And closing dams. Where the river branches off we close some of the chutes.

Q. Yes; some of the bayous and sloughs?—A. Yes, sir.

Q. Wing dams, closing dams, and riprapping?—A. And there has been some dredging; a little, not much as compared with what they do below.

Q. What has been the effect of these improvements upon the navigation of the river?—A. We think we have improved navigation, but it is hard to say just how much. It varies from year to year. This year, for instance, I think there has been very little trouble anywhere. For some reason, although it has been a dry season, there has been very little trouble; the river has kept up.

Q. Does the narrowing and confining of the river by levees and these wing dams and closing dams, as a rule, tend to the deepening of the channel?—A. Yes, sir.

Q. Permanently?—A. Yes, sir; you can hardly say it is permanent until we get the shore protected. There is, altogether, about 300 miles of caving banks on this 700-mile reach of the river, and we have, I think, considerably over 100 miles of shore protected; somewhere from

one-third to one-half is done. When it is all done there will be very little sand and mud coming into the river, and then we can say we have it under control. But at present, of course, there are a great many caving banks, and the depth of the channel depends a great deal on the way the water behaves in falling and sand bars fall more or less with the surface.

Q. They will settle down?—A. They wear off more or less. If they wear off uniformly at what we call crossings, where the channel comes on one side and then goes to the other side, there is where the trouble comes. In those crossings, if they are very wide and it wears down uniformly, then we are in trouble; we have very shoal water; but, on the other hand, if it happens to wear in one place more than the rest——

Q. On one side; yes.—A. And the boats keep that channel, then we have good navigation.

Q. That is like nature making a new wing dam?—A. Yes. There has been a revolution, I think (I think it is going to turn out that way), in the system of river improvements. The French have spent millions of dollars upon some of their streams, and they have changed their plans altogether.

Q. Please tell us in what respect.—A. In the way of treating the sand bars. They went, in the first place, on the principle, in general terms, that if you straighten the bends in a river and build wing dams to wash out the sand bars that you would improve navigation, but they found from the way things were going on that the sand bars would simply move down, and by straightening the river you diminish the friction and the holding-back principle of the banks. The bends and the additional length of the shore tend to hold the water back and prevent it from all running off at once——

Q. And the straightening increased the velocity?—A. And the straightening increased the velocity, so they found after all that while they were trying to improve upon nature they were not improving so much.

Q. And that increased velocity would tend to the river forming again new bends?—A. New bends and new sand bars, forming new obstructions.

Q. There is no certainty that the new channel would maintain itself permanently?—A. No. They think now that they have improved upon that. They are treating these sand bars more as a necessary evil, and they don't try to wash them all out, but simply to regulate, and instead of straightening the river, if the bends are not too great so as to impede navigation, they simply hold them there. And another thing: They have stopped, as I understand it, building high levees, but they allow the water to spread back over the ground in the way I was speaking of. Instead of building high levees and confining it in the channel they build very low ones.

Q. Build low levees and allow the water to overflow?—A. Yes; they simply try to direct the channel a little at these crossings, so as to facilitate navigation and prevent shoaling up too much.

Q. As an engineer, Colonel, what, if any, remedies would you suggest for diminishing the overflows or controlling the floods of the Lower Mississippi River? What would you recommend as to your part of the river, in other words? Supposing this portion of the river should be assigned to you and you were told to so manage your reach of the river as to aid in repressing the floods on the Lower Mississippi River, what would you do with your reach of the river?—A. I don't know as I would care to put down exactly what I would do.

Q. Well, this is, of course, simply asking you to express your opinion

on it, and what we are after is to get the opinions of men like yourself, who are experts in the matter.—A. I don't know that much could be done on this section of the river that would have much to do with it. I don't know that anything that could be done here would be of sufficient magnitude to have much effect.

Q. Nothing could be done beyond constructing reservoirs?—A. That is all I can think of, and whether they would be of sufficient importance might be a question. Of course, from what I mentioned about levees, you see I think we are going in the wrong direction in that respect, so far as floods are concerned, but that is a matter that I suppose can't be very well changed, they want that land and they are bound to have it. I have thought some that——

Q. Let me ask you this question, Colonel: Wouldn't it be cheaper for the Government to buy those bodies of land they are reclaiming by means of levees, and allow the lands to remain as permanent overflow basins? Wouldn't that be as cheap and as rational a way as any?—A. You know, Senator, that the Government gave that land away for the purpose of having them build these levees, originally.

Q. I wasn't aware of that fact.—A. That is so. Congress, in 1852, passed an act ceding all overflowed lands that had not been sold, to the States in which they were, with the distinct understanding that the proceeds should be applied to the building of levees and draining. And now they come and want the Government to build levees. I had a copy of that law made, and have it here.

Witness produced a copy of the section of the act referred to, which was marked Exhibit E, and is as follows:

EXHIBIT E.

[Extract from Revised Statutes of the United States, 2d edition, 1878.]

SEC. 2479. To enable the several States (but not including the States of Kansas, Nebraska, and Nevada) to construct the necessary levees and drains to reclaim the swamp and overflowed lands therein—the whole of the swamp and overflowed lands made unfit thereby for cultivation, and remaining unsold on or after the twenty-eighth day of September, A. D. eighteen hundred and fifty, are granted and belong to the several States, respectively, in which said lands are situated: *Provided, however*, That said grant of swamp and overflowed lands, as to the States of California, Minnesota, and Oregon is subject to the limitations, restrictions, and conditions hereinafter named and specified, as applicable to said three last-named States, respectively.

SEC. 2480. It shall be the duty of the Secretary of the Interior to make accurate lists and plats of all such lands and transmit the same to the governors of the several States in which such lands may lie, and at the request of the governor of any State in which said swamp and overflowed lands may be, to cause patents to be issued to said State therefor, conveying to said State the fee simple of said land.

The proceeds of said lands, whether from sale or by direct appropriation in kind, shall be applied exclusively, as far as necessary, to the reclaiming said lands by means of levees and drains.

SEC. 2481. In making out lists and plats of the lands aforesaid all legal subdivisions, the greater part whereof is wet and unfit for cultivation, shall be included in said lists and plats, but when the greater part of a subdivision is not of that character, the whole of it shall be excluded therefrom.

The WITNESS: The appropriation acts are worded something like this: "For improving the navigation of the Mississippi River between" such and such places, "by confining the river within its natural and artificial banks," so many dollars. The appropriations are not made for "protecting land," but I have always stated as my opinion in my reports that it would not improve navigation. That is a matter, though, for Congress to say.

Q. Isn't it apparent that these overflows in the lower section of the

river are to a large extent caused by the fencing in (I use that non-technical expression) of large natural basins that were formerly open to the Mississippi River at high water?—A. I don't know as I could say "to a large extent," but I think I could safely say "to some extent."

Q. And continuing to fence in more and more of those basins, or reclaiming more and more of those bottoms, simply aggravates the situation to some extent?—A. That is my opinion; yes, sir.

Q. And it becomes really a question, then, of which is the cheaper—to keep building higher or bigger levees or to leave those basins open to hold the surplus water?—A. Yes, sir.

Q. Isn't that the problem in a nut shell?—A. Yes sir.

Examined by Mr. BERRY:

Q. Colonel, has the water been any higher in the lower river this last year than it was before levees were built to any great extent?—A. I haven't the records, Senator, for the lower river.

Q. You can't say, then, that the flood tide has been increased at all, can you?—A. Not from the records. All that I have said is just from the principle of the thing.

Q. You can't say from any accurate knowledge that it has increased at all?—A. No, sir.

Q. You can't state that it has been higher since the building of the levees than it was before they were built?—A. I am under the impression that it has been, but I can't say, of course, because I haven't the records here; but I could hunt them up.

Q. Do I understand you, Colonel, to say that in your opinion the narrowing of the channel tends to lower the channel rather than to raise it; that a scouring process goes on that tends to deepen the channel; that the bed of the channel rises or goes up by reason of confining the water to a narrower space?—A. It depends on what kind of confining you mean. If you mean confining the high water (that is when the sand bars form, you know), during that time the bottom would rise, I think, if you confine it; but when the water is falling the channel cuts out; it doesn't cut out much while the water is at flood stage. We find the same thing in the ocean. In building jetties out at sea we find that the low tide does the wearing, the cutting away; flood tide doesn't wear the bottom much, doesn't affect the bottom. You know that even in a big storm at a certain depth the light sand will remain unmoved—in a tremendous storm if the water is deep enough; but if it gets shallow the water affects it. So we build our wing dams only a little way above low water, and I believe that is the best practice.

Q. On a leveed river, where the water is confined, taking high and low water all together, can you state whether the bed of the river is lowered or raised by reason of the confining of the water and straightening the river and keeping it in a narrower channel than it would be but for the works?—A. As a general rule I think it would gradually lower it a little. Some claim the other way, though. That is only my opinion.

Q. If a river is leveed, by its natural banks or otherwise, if there is a break or outlet in high-water tide, I will ask you if it is not the effect of that to form a sand bar immediately below that break to collect the sand or mud or whatever it is immediately below where the break comes; isn't it the tendency to form a bar just below or near the break?—A. I never have seen that done. I know it is claimed that way by some, claimed that it will, but I have never seen that in my experience—never have had a chance, for that matter, to observe it.

Q. Your knowledge, then, about the levees is not from actual work

connected with the levees, to any great extent, but more from general information on the subject and the river?—A. That is right. I have never been on the part of the river where they have many levees.

Q. What is the effect of these reservoirs at the head waters of the Mississippi upon the river below St. Paul? When water is released from the reservoirs does it increase the depth of the river below St. Paul; and if so, to what extent and for what distance?—A. As near as we can make out, it affects the river down as far as Red Wing. I have here the official report of last year, showing that there was a rise of about a foot at St. St. Paul, due, as near as they could make out, to the reservoirs, and that it gradually diminished until it got down to Red Wing. Red Wing is down by Lake Pepin, and there it was inappreciable.

Q. I think it was a little over a foot at St. Paul.—A. Well, it is pretty hard to determine exactly, because the natural condition of the water varies anyway. You have to take a kind of an average.

Mr. BERRY. What is the distance from St. Paul to Red Wing by the river?

The WITNESS. About 52¼ miles.

Q. You have built some levees between here and the mouth of the Missouri River, and are building some now, are you not?—A. Yes, sir.

Q. Do you do that with a view to improving the navigation of the river, or do you do it to protect the land?—A. Congress says it is for the improvement of navigation of the river.

Q. Do they direct you to build levees to do that?—A. Yes, sir.

Q. In the act of Congress?—A. Yes, sir.

Q. Aren't you mistaken about that?—A. No, sir.

Q. Doesn't it say they may do it by this system or by the other?—A. No, sir.

Q. They say you shall build levees?—A. I can get the act in a moment.

(Appropriation act of Congress was shown to the committee by the witness.)

Q. Then I understand you to say, Colonel, that for the improvement of the river you would not build these levees?—A. That would be my judgment.

Q. Not to build any levees at all, anywhere?—A. I don't know whether I could say that or not. I think the levees are for the improvement of the land, not for the improvement of navigation; that is the way I look at it. But that is a matter for Congress to say, and I am working under orders.

Q. Well, we want to know what Congress ought to do about it; we would not be here otherwise. We want your opinion about it; we may not follow it, you understand, because other men may think differently.—A. They do think differently; I can tell you that right now.

Examined by Mr. GALLINGER:

Q. Do you have any special difficulty in maintaining the levees that have been built between Rock Island and St. Louis?—A. Yes, sir; there is some difficulty. The rats, they think, are the cause of the breaks. We had one break last year, and it occurred very suddenly. The people in the neighborhood and State commissioners hire patrols, and divide the river into short sections, and watch them during the high stages of floods. The break which occurred was within a few minutes of the time when the patrol had passed.

Q. Was that break in an old or in a modern levee?—A. It was a new one. As they get older and more settled there will probably be less trouble; but in some places it is impossible to get suitable material—

there is too much sand in the material—and the theory is that the rats burrow in to about the middle of the levee, and the water finds its way that far and then pushes through, undermines the levee, and it goes out so quick that they can do nothing to save it. The only thing they can do is to protect the ends from wearing away any more than can be helped.

Q. Do I understand, Colonel, that wing dams are designed to accomplish the same result as jetties—to narrow the channel and increase the rapidity of the flow?—A. Yes, sir; the wing dam is really the jetty, you might say.

Q. It is one form of jetty?—A. It is another name for it; yes, sir.

Q. Perhaps, repeating the question Senator Berry propounded, I want to ask whether or not in your opinion the levees between Rock Island and St. Louis are necessary to the interests of commerce?—A. I think they are not.

Q. Colonel, this inquiry involves several questions, and among others is the question as to the effect of denuding the forests at the source of the water supply of the Mississippi River upon the floods. Have you ever had occasion to make observations that would justify you in expressing an opinion as to that matter?—A. No, sir; I have never had anything to do in that direction at all.

Q. Where were you stationed before coming here, Colonel?—A. I was stationed at Willets Point.

Q. Have you had any service on the Lower Mississippi?—A. Not at all. On one of the tributaries only—the Tennessee.

Q. Have any matters that have come under your observation given you information that would warrant you in expressing an opinion as to the advisability of attempting to control floods on the Lower Mississippi by diverting the water through an artificial outlet into Lakes Borgne and Pontchartrain, as has been advocated and discussed by some?—A. No, sir; I don't think I could give any useful information on that subject.

Q. Are you extending the levee system on the reach of the river under your control?—A. Yes, sir; we are making surveys now with a view to extending it, and we are actually at work at them now. Some of them are being extended and some have been surveyed with a view to appropriations by Congress.

Q. As a matter of fact, Colonel, in view of this statute to which you have called the attention of the committee, the Government is now engaged in building levees to protect property that was ceded to the States with the specific understanding that they themselves should protect their property?—A. I so understand it; yes, sir.

Q. By way of recompense for the land?—A. In order to state positively, though, it would be necessary to find out, in the case of any given tract of land, at what date it was occupied. Land sold before 1852 was not sold with that view, as I understand it.

Q. Do you know of any points on this river where reservoirs could be built at any reasonable cost and the water diverted for the purpose of irrigation?—A. No, sir; I do not. There may be places, but I am not familiar with any.

Q. Would not the expense of building reservoirs at any point on the river and diverting the water through artificial channels into the arid or semiarid regions of this country be enormous?—A. For this river?

Q. Yes.—A. I don't suppose it could be done. I don't know of any region on this river that would be considered arid.

Q. Well, the Missouri, we will say —A. Well, I don't know. I don't think there is any large area that could be used that way.

Q. I asked the question because we are charged, among other things, with inquiring into the question of the possibility of storing the water and using it for purposes of irrigation.—A. I am not familiar enough with the Missouri to say positively, but I don't know of any place where it could be done.

Examined by Mr. BERRY:

Q. Colonel, are you building any levees except for the purpose of continuing the work of constructing artificial banks from the mouth of the Flint River, running along the west bank of the Mississippi River to the mouth of the Iowa River? Is that the only levee works you are engaged in building below here?—A. No; there are two other places, I think, where they are at work now.

Q. On levees?—A. Yes, sir.

Q. Are they doing that work under your supervision and direction?—A. Yes, sir.

Q. You ordered it built that way?—A. Yes, sir.

Q. And this provision here (of an act of Congress) is where you say you are directed to build levees?—A. I so understand it; yes, sir.

Q. And you are building in other places besides the places covered in that specific direction?—A. No; there are other directions. That is not the only one. In each case where an appropriation for levees is made by Congress, it is in such terms as those.

Mr. NELSON. The Warsaw and Sny levees have been ordered by acts of Congress?

The WITNESS. Every levee that is built is ordered by act of Congress. I am not building any on my own hook.

Q. You said your authority for building levees came from this (act of Congress). Now I ask you if you are not building levees on parts of the river not included in this?—A. I am not building any except what are authorized under just such provisions as that.

Q. But you are building others besides this one to which I refer here, are you?—A. We are building two; yes; and have been making surveys for some more.

Q. In your opinion, then, that is money thrown away and you ought not to build those levees; do I so understand you?—A. I don't say it is throwing money away. I say that is the order of Congress, and it doesn't agree with what I have reported officially; that in my opinion this does not improve navigation. Nevertheless, Congress made the appropriation, and that ends it with me.

Q. You think, then, that the levee work you are doing up here does not improve navigation?—A. That is it; yes, sir; and I so reported to Congress in my official report. I reported, "While I am not of the opinion that the construction of such banks as herein proposed will be of any benefit to navigation, yet it may perhaps be of interest to submit some figures concerning advantages to the land inclosed." That is about as much as I cared to say, inasmuch as Congress had ordered the survey.

Examined by Mr. GALLINGER:

Q. Colonel, are the lands that would naturally be overflowed if these levees were not built, on the reach of the river under your control, valuable or otherwise?—A. I had an estimate made at the time of two of these surveys. As near as they could get at the value, before the levees were built the land was worth in the neighborhood of $5 an acre, and it was estimated that after the levees were built it was worth from $25 to $30 an acre. I stated that in one of my reports.

Q. Then, according to that statement, the building of the levees at

least quadrupled the value of those lands; is that correct?—A. Yes, sir. That was the estimate I had made by the engineer on the spot. I told him to inquire of the people in the neighborhood and find out all he could about it, and that is what he reported.

Examined by Mr. NELSON:

Q. Colonel, you stated (in reply to Senator Gallinger, I believe) that you are now engaged in making surveys for other levees on your reach of the river?—A. Yes, sir; during the past year.

Q. Will you please state at what points?—A. The first survey is from Quincy down to the Sny Levee.

Q. That would practically amount to a closing in of the gap between the Warsaw Levee and the Sny Levee?—A. Yes, sir.

Q. That is on the east side?—A. And I think there is another one on the west side, from Lagrange to Hannibal; that has been made.

Q. And it is from Quincy down to the Sny that you are working now?—A. Yes, sir.

Q. Are there any others?—A. I don't think of any just now. Yes; I think there is still another.

Q. That must be from Muscatine down to the Iowa River.—A. That is right; yes. That is nearly completed; they are at work, though; and surveys from Drewry's Landing to New Boston and from Skunk River to Fort Madison have been completed.

Examined by Mr. BERRY:

Q. Colonel, if I understood you correctly in your original testimony, when you were answering questions of Senator Nelson, you think this manner of improving the river has all been a mistake; that it would have been better, except where very crooked, to have had the water run in the regular channel; is that what I understood you?—A. To hold the banks where they are; yes, sir.

Q. Then all this money that has been appropriated by the Government for the improvement of navigation has not done any good at all. According to your idea it would have been better to have let nature alone?—A. Oh, no. Where they have attempted to straighten the river and to control it altogether I think generally they have found it has simply transferred the trouble from one place to another, and that what they wanted was to get nature to help them—work with nature. That, I believe, is going to be the plan.

Q. And you think that, however far the Mississippi may spread out anywhere, it is a mistake to try to stop that spreading at all?—A. At high water, yes, sir; not at low water, though. There is a difference. I tried to explain that. At high water let it spread out to diminish the floods below, allow the water to spread out and soak into the soil and gradually filter back into the river at low water; at low water there is not water enough to fill a broad channel to the proper depth for navigation, and then you have got to narrow it; that is a case of necessity.

Q. Have got to narrow it?—A. Have got to narrow it for low water.

Q. Can not you narrow it by means of a levee?—A. No, sir; you will find, if you look at the records, that in a number of years the levees were not touched at all by the floods. The flood does not come up to them, and they are from six to twelve feet above the ordinary low-water surface, so they can not have any possible effect upon low-water navigation.

Q. Or on the river in ordinary stages, even?—A. Or on the river in ordinary stages, even; it is only the extreme floods. You will find that year after year the flood does not reach the levee at all.

Q. Do you mean on the lower river?—A. No.

Q. You are talking about the upper river?—A. Yes; right here on this reach; yes, sir. Even ordinary floods don't reach the levees, so they certainly can't do much toward improving navigation.

Q. Well, Colonel, to put it in a narrow compass, just what kind of work do you think does improve navigation? You say that straightening the river does not, except where it is very crooked, and that the levees do not. Now, tell me what you think does.—A. Well, just what I tried to explain before, holding the banks from caving in and straightening where the curves are too abrupt, and directing the current at crossings so, when the water begins to fall and the bar begins to get too shoal, that the water will wash out in one place instead of washing gradually across a great broad surface and keeping very shallow water on top of the bar.

Examined by Mr. NELSON:

Q. As I understand you, Colonel, there is an entirely different effect upon the scouring and deepening of the channel of the river produced by wing dams and closing dams from that produced by levees?—A. Yes, sir; entirely.

Q. That the mere building of levees does not necessarily tend to the deepening of the channel of the river at low water?—A. I think it does not.

Q. That to improve the navigation of the river at low water (and that is the object of river improvement) you have got to operate on the river at its low stages by such a system of riprapping and wing dams and closing dams as exists in the upper river?—A. Yes, sir.

Q. And that although confining the river by means of levees may scour and deepen the channel to some extent, the scouring and deepening of the channel is not at all commensurate with the flood basin that you cut off from the river; that is, the new basin you make in the bed of the river bears no proportion at all to the basin you have taken away from the land side of the river by the building of the levees. In other words, you deprive the river of large flowage room on the outside, and in lieu of it you get a possible deepening of a few inches in the bed of the river. Isn't that the effect of the levee system?—A. That is my opinion of it; yes, sir.

Q. And in regard to the Lower Mississippi, wouldn't it strike you that to improve the navigation of the lower river the channel should be confined, preventing it from scattering; would not that process be the most available there, too?—A. I don't know; I wouldn't care to give much evidence in regard to the lower river, because I am not sufficiently familiar with it.

Q. Isn't it a fact that when the lower river spreads out it forms a number of bayous and sloughs in all directions?—A. I so understand; yes, sir.

Q. And if when the river subsides you can confine the water to one main channel, doesn't that improve navigation in a more substantial form than the other?—A. Do you mean not to allow it to spread out at all?

Q. Not to allow it to spread, but confine it within one main channel.—A. Well, it is possible that allowing it to expand on the lower river might have a different effect from what it has on the upper river, because all the water held back to keep the crest of the flood down (prolong the flood as it were) has got to get out, and down toward the mouth of the river you simply have to take care of the water; you don't want it for any purpose; you are simply getting rid of it.

Examined by Mr. BERRY:

Q. Don't you think, also, that the clearing off of the forests, the cutting away of the underbrush, the tilling of the soil, the putting in of these tile drains, and all that, has tended to make the rise of the river more rapid than it was in the olden time before the country was cleared up?—A. Yes, sir; I think there is no doubt about that. For instance, if the entire surface of the country were smooth (frozen, for instance) so the water couldn't soak in at all, and there was no vegetation to hold it, it stands to reason that the water would run into the river quicker, and the river would rise more rapidly.

Q. But the duration of the flood would be lessened?—A. It would last for a shorter time; yes, sir.

Examined by Mr. NELSON:

Q. Isn't it a matter of fact that the great distinguishing feature of the flood of 1897 was the unusually long duration of the high water?—A. I think it was.

Q. Longer than ever before. As a matter of fact we have had higher stages of water at Cairo and other places in former floods, but never so lengthy.—A. Never so lengthy, I think. I would have to look up the records to be sure about that.

Examined by Mr. BERRY:

Q. Do you know, Colonel, whether any of the lands that are now subject to overflow by the Mississippi River are lands which were included in the swamp act and which were given to the States? Those that are actually flooded by the Mississippi; not by its tributaries, but by the river itself?—A. No, sir; I do not; I have no positive knowledge of it.

Q. You don't know whether they were all deeded by or purchased from the Government prior to the acts of 1850, 1852, and 1857, or not?—A. No, sir.

Q. Do you know how much money the States have expended on the river below?—A. No, sir; I don't know how much they have expended.

Q. You don't know whether they have expended as much as the value of the lands they received, or not, in the way of building levees?—A. No, sir.

Examined by Mr. NELSON:

Q. Will you furnish us with the figures as to the stages of water as affected by the reservoirs?

In response to the last question, witness produced the following statement, marked Exhibit F:

EXHIBIT F.

EFFECTS OF THE RESERVOIRS AT HEAD WATERS OF THE MISSISSIPPI RIVER.

[Extract.]

* * * * * * *

To sum up the effects of the reservoirs on the river at St. Paul for 1893, 1894, and 1895, the result of retaining a part of the summer low water in the reservoirs has been to reduce the stage probably more than 0.2 foot; the result of discharging from the reservoirs the increment of 2,000 to 2,500 cubic feet per second has been to raise the water after the river has settled to a comparatively stationary low stage, about 1 foot, and to maintain this increased stage, though this increase has usually arrived two to four weeks too late for the best interests of navigation.

The effect at Hastings has been not quite so marked as at St. Paul, while at Red Wing, so far as my observation goes, the effect has been inappreciable.

* * * * * * *

Very respectfully, your obedient servant,

J. D. DU SHANE,
United States Superintendent.

ST. PAUL, MINN, *September 9, 1895.*

Q. In your opinion, has not the effect of these improvements on the upper river, from here clear to the head waters, by means of the reservoirs and of the wing dams and closing dams, the riprapping, etc., been to equalize the flow of water in the river and on the whole to diminish high water or to reduce the high-water period?—A. The reservoirs undoubtedly have some effect, but you can not tell exactly what it is. It is like the waves coming in on the ocean. A wave will come in, and then one a little higher, and a little higher, and then one lower, and lower, and lower. There are waves upon waves. It is a complex affair. Some years we may have a great deal of rain coming in such a way as to make floods, and another year we may not. Sometimes we get floods away along in the summer here, without any particular reason at all for their coming. So you can not tell. Now, look at that flood there [pointing on a map]. It was a dry time of the year. There was a flood beginning in September and running into December.

Q. The main flood feeders of the Mississippi are the St. Croix, the Chippewa, the Black, the Wisconsin, on the east side, and on the west side, the Des Moines and the Iowa?—A. Yes; and I think there is one above the Des Moines.

Q. Well, you are not prepared to say, then, that the effect of these improvements has been to diminish the floods?—A. On general principles, water held back during the floods and let go in the summer time must have that effect, but I don't think the river improvements would have very much effect either way on that. What we are after is low-water navigation. High-water navigation takes care of itself.

Q. On the whole, then, you would ascribe these changes in the high stages of water to changes in rainfall?—A. I think so; yes, sir.

Q. That these lower stages we have had of recent years has been, on the whole, owing to diminished rainfall?—A. There may be the same amount of rain falling, and in the same time, and yet one rainfall may make a bigger flood than the other, in this way: Suppose the rain begins falling up around your reservoirs, and gradually extends down along the river, coming down at about the same rate that the water comes in the river, and keeps gradually coming down lower and lower until finally, when it gets into the Senator's (Mr. Berry) country it is raining on top of the flood; then you would have the highest kind of a flood. On the other hand, suppose we had a heavy rain and there was a flood in the lower river, coming out of the Tennessee and other tributaries; there may be a flood in the lower river and none up here at all. This is only a small part, you see. One of the biggest floods in the lower river was caused principally by a flood in the Tennessee and Cumberland. It depends on the direction in which the storm is progressing. If a rain storm commences at the head waters first and goes down as the water goes down in the river, you get a high flood; but if it commences on the lower river and gradually works up, you may have no flood at all, to speak of, and the same amount of rain may fall in the same period of time.

Examined by Mr. GALLINGER:

Q. Colonel, wouldn't two or three dry seasons have some effect upon that, likewise?—A. Yes, sir.

Q. Suppose we had two or three dry seasons and then had very heavy rains, a much greater amount of the water would be absorbed than if you had two or three successive wet seasons?—A. Yes, sir; and frozen ground has a great effect.

Q. A winter freshet on frozen ground is liable to be more destructive than on ground which is not frozen?—A. Very much so; yes, sir.

Q. The water runs off quicker?—A. Yes, sir.

Q. And so with cultivated ground, more rapidly than on timber ground that is in a state of nature?—A. Yes, sir.

GEORGE LAMONT, having been duly sworn, testified as follows:

Examined by Mr. NELSON:

Q. Captain, where do you live?—A. In Rock Island.

Q. How long have you lived here?—A. Forty-two years.

Q. You have been engaged in steamboating during that time?—A. Not as a navigator very much. I have done some of it. I have been representing steamboat lines here for quite a number of years.

Q. And have been acquainted with steamboat navigation on the upper part of the Mississippi River?—A. Only from what I have heard the steamboat men talk; I gather a good deal of information from that.

Q. Will you please tell us what, in your opinion, has been the effect of the improvement of the river of recent years upon the navigation of the river?—A. Since I first came here—of course I was interested in the steamboat business—and at that time there were times that boats could get to St. Paul later than other times; but since these improvements have been going on I haven't seen the time but what boats could get there.

Q. To St. Paul?—A. To St. Paul; a great deal later than they could in the early days.

Q. Since the reservoirs were built the navigation has been better to St. Paul than it was before?—A. I think so; yes, sir.

Q. In the low stages?—A. Yes.

Q. The reservoirs and the other improvements in the river?—A. Yes, sir. I know it for a fact.

Q. You know it to be a fact?—A. Yes, sir.

Q. Have you of recent years been up along the river on boats?—A. Not for the last seven or eight years; but it is from the business I do with the boats, you know, in shipping and receiving goods. My company tells me whenever they can't get to a place not to receive goods for that place. That is the way I know it.

Q. You know it from your familiarity with the traffic on the boats?—A. Yes, sir.

Q. And the navigation at low stages of water has been much better since the reservoirs were built than before?—A. Yes, sir.

Q. What can you tell us about the matter of floods and overflows of the Mississippi River?—A. I could simply give you my ideas of it.

Q. That is what we want, Captain—your idea of what causes them and the best way to protect the country against them.—A. When I was up and down the river, twenty or twenty-five years ago, I noticed we would run across those very high bars in the river (bluff bars), and right along in the river the water would be moderately deep, enough to navigate along, and of late years I don't find any of those. They are

scattered—spread out more over the river—and I presume that comes because it don't cut out; it don't fall and leave these high bluff bars there. I recollect Mr. Reynolds—I presume you may have heard of him——

Q. Yes; Diamond Jo Reynolds.—A. He was standing down here on the levee talking to me one day about twenty-one or twenty-two years ago. It was low water and he had boats stall and barges, and he had a good deal of trouble, and he said he thought the best thing they could do with this river to improve it would be to riprap the banks, and when the water was low and there was a crossing became bad to throw a dredge boat or two in there and dredge out an opening and the channel would cut its way through very rapidly. That was his idea, and I thought at the time it was a pretty good idea.

Q. And they have been carrying out that idea, haven't they, in riprapping the river at a great many places and building these closing and wing dams?—A. Well, he never liked the idea of the dams. His idea was to riprap the banks and close up the sloughs.

Q. Well, those are closing dams, you know. Have you taken any particular notice or observation of the floods in the river? Have there been more floods of recent years than there used to be, or floods of a more aggravated character?—A. I think the water has been higher. I account for that on the ground that the bed of the river is filling up and that the same volume of water has got to pass over, and of course the higher the bed the higher it comes up to the bank.

Q. You think there has been a general filling up of the bed of the river?—A. Yes, sir.

Q. All along?—A. All along.

Q. And that the water goes up with it?—A. The water of course goes up with it. The same volume has got to pass over as passed over when it was deeper.

Q. And you think that has added to the overflows?—A. I think so.

Q. In your opinion what can be done to furnish relief against these overfloods or flooding of lands on the Lower Mississippi?—A. Well, I don't know as to that, only I think the improvements they are making now will eventually, when they get the banks riprapped so there will be nothing to run in, that it will scour itself out and draw the water in and deepen the bed of the river.

Q. What do you think the effect of the levee system is upon navigation and on the matter of floods and overflows, Captain?—A. I don't know as they will hurt navigation; I think they will help navigation, but of course the water is going to raise higher if you shut it off and don't let it flow back on the land.

Q. You think, then, that building levees has a tendency to increase the floods—to raise them, at all events?—A. To raise the water, yes, unless they can find some ways and means to deepen the bed of the river.

Mr. GALLINGER. Excuse me for interrupting, Mr. Chairman, but the Captain gave an opinion that does not seem to be justified by the record—that we are having more floods or higher water now than formerly. By examining the official figures I find that from 1880 to 1889 the average height of the high water was very much greater at St. Paul, Dubuque, Rock Island, Keokuk, and Hannibal than it has been from that time to the present. St. Louis is the only exception, the high water there being higher from 1889 to 1897 than for the period between 1880 and 1889. That in all cases except St. Louis for the eight years from 1880 to 1889 the average was greater than from that

time to the present. Take it, for instance, at St. Paul. In 1881 it was 19.5 feet, this year 17.5, this year being the next highest year. At Dubuque in 1880 it was 22.7; in 1881, 21.2; in 1888, 22.4, while this year it was 17.9. In 1880 Rock Island had 18.4; in 1881, 17.7; in 1888, 18.6; in 1892, 19.4, while in 1896 it was only 12 and in 1897 it was 15. The same is true of the other places. It is very marked at St. Louis, where in 1880 there was 25.4 feet; in 1881, 33.7; in 1882, 32.4; in 1883, 34.8, and this year it was but 22; and for the eight years a much less amount, with the single exception of 1892, when they had very high water there—exceeding that of any other year, I believe. What I wanted to bring out was the fact that for the eight years previous to 1890 there was higher water than they have had since at all those points on the river.

Examined by Mr. BERRY:

Q. Have you ever been on the Lower Mississippi River?—A. Only two or three trips; that is all.

Q. All you know about it is from your general information in regard to the river?—A. That is all.

Q. And your idea that the bed of the river has raised is not based on measurements made, or anything of that kind, but is just a general notion of yours, as I understand it?—A. Just a general idea that it has gone up.

Q. You have an idea that the bed of the river is higher than it used to be, but you haven't ascertained that by measurements of what it formerly did as compared with what it is doing now?—A. No; that is, the bed of the river has raised, including the channel; the channel has filled up, too, so it spreads out more. In former years it used to draw in and leave these high bars—draw in to a little deep channel—but now it spreads over a greater space.

Examined by Mr. NELSON:

Q. In respect to that portion of the Mississippi River from the mouth of the Missouri up it is only at high water that the levees do any good—that is, pen up the water—isn't it?—A. That is the only time.

Q. It is only at high water that the river gets so high as to reach the levees?—A. Yes.

Q. And at that stage of the water they don't amount to anything, particularly as to aiding navigation?—A. No.

Q. There never was any difficulty in navigating the river from here to the Missouri River before those levees were built, was there?—A. Only in extreme low water.

Q. But in extreme low water those levees couldn't be of any assistance?—A. No.

Examined by Mr. GALLINGER:

Q. Captain, has the business of steamboating in this vicinity increased or decreased during the past ten years?—A. Well, in some commodities it has increased. In the lumber business——

Q. Well, in the aggregate, has it increased or decreased, should you judge?—A. I think it has increased.

Mr. NELSON. Taking lumber into account, and shingles?

A. Yes; that overcomes what it has been reduced in merchandise. Of course, that is what has been against us mostly here. We start out in the spring of the year with a pretty good business, and just about the time we are at the height of our business low water comes on and we can't do much. It cuts away from the shippers the advantage we

have over all-rail freight. Our differential on the river, when we can navigate without any trouble, is so much less than the rates by rail that it is a big advantage to the shippers; but when the low water comes on we can't afford to navigate and do this business for the rates we did, because we can't carry enough on the water.

F. C. DENKMANN, having been sworn, testified as follows:

Examined by Mr. NELSON:

Q. Where do you live, Mr. Denkmann?—A. At Rock Island.

Q. What business are you engaged in?—A. In the lumber business.

Q. What branch of the lumber business?—A. Well, here, in the manufacture and sale of lumber.

Q. Are you familiar with the navigation of the Mississippi River from here to St. Paul?—A. I am somewhat acquainted with it.

Q. In what way have you become acquainted with it?—A. We employ steamboats in taking logs to our mills from the North.

Q. With what firm or corporation are you connected in business?—A. Weyerhauser & Denkmann.

Q. And you are engaged in shipping lumber upon the river here, in large quantities?—A. Well, we tow logs down in contradistinction to lumber, because lumber is also towed down the river.

Q. Well, what are you engaged in—in towing logs or lumber, or both?—A. We tow logs to our mills here and at Davenport, and saw them into lumber.

Q. Where do you take logs from—from the Chippewa?—A. The Chippewa, the St. Croix, and the Upper Mississippi.

Q. Beyond St. Paul?—A. Yes, sir.

Q. Please give us what information you can as to the navigation of the Mississippi River and the changes within the last ten or fifteen years.—A. It is rather hard to give any detailed account, because I can't carry so many things in my head.

Q. Well, give us what you know and what your experience has been.—A. In a general way we believe that the works of the Government on the river have improved navigation. Our pilots so report to me.

Q. Navigation is better now than it used to be?—A. Than it was formerly; yes, sir.

Q. Clear up to St. Paul?—A. Yes. We don't go to St. Paul; we really only go as far as Prescott, on the way to St. Paul.

Q. Prescott is at the mouth of the St. Croix?—A. Yes, sir.

Q. Have the reservoirs had any good effect on the river?—A. I really don't know. I understood that they only opened them for the first time this year, and we have had a fair stage of water right through the year, but how much of it was due to the reservoirs I don't know.

Q. In what way has the river been improved below here—by means of these wing dams and closing dams?—A. Yes, sir.

Q. And riprapping?—A. Yes, sir.

Q. Are you familiar with the levees on the river here?—A. No, sir.

Q. Don't know anything about that question?—A. No; I have never been down the river below Muscatine.

Q. And you don't know what effect the building of levees has on the navigation of the river?—A. Not from actual experience.

Q. Well, do you know from what you have learned from steamboat men and men engaged in the navigation of the river?—A. Well, our business has always been above here, so our steamboat men are not familiar with that branch of the stream.

Q. Are you familiar with or do you know anything about the floods in the river?—A. Well, I have observed them as they have come; yes, sir.

Q. Have they been greater of recent years than formerly?—A. No; I think not.

Q. The river, on the whole, has been in better shape of recent years than formerly, hasn't it?—A. Well, the average of the stage this year was much better than any year for a long time.

Q. Don't you think, Mr. Denkmann, that the tendency of these river improvements has been to equalize the flow of water in the river, to check it in high water and to increase it during low water?—A. I don't see how it could. The reservoirs of course may stop some of the water in the spring when the floods are on, but only to that extent could they make any difference; because the water must run off.

Q. Well, deepening and improving the channel of the river must necessarily have aided in carrying off the water more rapidly?—A. Well, that only occurs during low water, and of course the wing dams cause the river to scour out a channel, throwing the water to one side or the other.

Q. The wing dams are very useful for that purpose, are they not?—A. We think so; yes, sir.

Q. At low water?—A. Yes, sir.

Q. And the best thing that has been invented for that purpose?—A. So far as we know.

Q. What, in your opinion, can be done to diminish or check the overflows of the Mississippi River?—A. The only way I can see would be to increase the reservoir system north of St. Paul.

Q. Do you know of any other places along the river that would be suitable for reservoirs?—A. No, sir.

Q. How about the Beef Slough Basin? You get a lot of logs out of that, at the mouth of the Chippewa River?—A. Well, the Chippewa River fills that up in high water.

Q. So you couldn't hold any water there?—A. No.

Q. Wouldn't Lake St. Croix make a good reservoir?—A. Well, the shores are high enough, of course, so you could dam it to most any height.

Q. And Lake Pepin?—A. The same is true there.

Q. Can you think of any other places on the upper river that, if the question arose of relieving the river by means of reservoirs, would be more suitable or afford larger holding grounds than those two places?—A. Do you mean south of St. Paul?

Q. Yes.—A. I don't think I know of any. The bluffs are close to the river nearly all the way down from St. Paul.

Q. Lake Pepin forms a fine basin?—A. Yes, sir.

Q. And so does the St. Croix. There couldn't be any at the mouth of the Chippewa; none at the mouth of the Black River—at La Crosse, between La Crosse and Onalaska?—A. I think not.

Q. Unless you overflowed the country for miles and miles back?—A. No, sir.

Q. None at the Wisconsin?—A. No; I think not.

Q. And none on the west side of the river at any place?—A. The bluffs are rather close to the shore all the way down, as I remember it.

Q. So that, so far as the reservoir system is concerned, the only points between St. Paul and Rock Island, where there would be any fair opening to pen up and hold water in large quantities, would be those two points, would they not?—A. Yes, sir.

Q. St. Croix River and Lake (the Lower St. Croix) and Lake Pepin?—A. Yes, sir.

Q. The navigation of the river has been much better of recent years than it was formerly, hasn't it?—A. Yes, sir.

Q. What do you ascribe that to?—A. I ascribe it to the Government works on the river. We have been able to bring rafts down during extreme low water, whereas in earlier years we were obliged to stop altogether during the summer season, when the water got so very low.

Q. Navigation, then, has been much better during the low stages of water, of recent years, than it was before the Government improvements were made?—A. Yes, sir. I know that from our own observations and from what our pilots report.

Q. These advantages have been derived, then, partly from the reservoirs, partly from these wing dams and closing dams?—A. I can't say as to the reservoirs; I don't think we ever received any service from them before this year, and there has been pretty fair navigation all the year, so I couldn't tell what that amounted to; of course it amounted to something, because it sent some water into the river, and it is water that we need for navigation.

Q. I think the gauges show that the effect of the reservoirs upon the stage of water has been chiefly between St. Paul and Lake Pepin.—A. Well, we use the river between Prescott and Lake Pepin.

Examined by Mr. GALLINGER:

Q. How long have you been engaged in the lumber business?—A. I have been personally engaged in it since the summer of 1880.

Q. Approximately, what distance, in miles, do you navigate the river?—A. I really don't know. We call it in round figures 400 miles to Stillwater, but it may be more or less; I don't know.

Q. When you say that the Government improvements have improved navigation do you speak from actual personal knowledge or from statements of others?—A. From the fact that we are able to use the river to better advantage than we formerly were.

Q. Have you made any calculation on that point covering a period of, say, ten years before these improvements were made as compared with the present, or do you jump at the conclusion that because some particular year there was very low water and you couldn't get down the river and this year you can get your rafts down therefore it is better?—A. No; I think our general experience has been such, and our pilots have reported the condition of the channel in various places where the Government has put in dams.

Q. Was your business ever very much obstructed during the summer months; that is, was there ever any considerable period when you couldn't get rafts down the river, that you can recollect?—A. Yes; there have been times when we have had great difficulty in getting them down. I can't just recall the details, because I didn't charge my mind with them. But a year or two ago, I don't remember just the year, the river was down below what we call low-water mark, and we were able to keep our boats going; and in former years, although it never got so low in my recollection, I don't think we could have navigated at all.

Q. Your testimony doesn't seem to agree with that of Colonel King. He says he thinks the confining of the water and carrying it off more rapidly is a detriment to the river at low water; that you would have more water if this water was allowed to spread out, and that during the low-water period it would influence the stream to a certain extent.—

A. I think I heard the Colonel's testimony on that point, and I understood him to say that when it overflowed the banks the water was retained, which I think is true, and then it returned to the river, to the improvement thereof.

Examined by Mr. NELSON:

Q. The navigation of the river that you are particularly familiar with is the pulling down of rafts of logs by steamboats?—A. Yes, sir.

Q. And that you are more extensively engaged in than anybody else on the river, are you not?—A. Well, I can't say that, but I presume as much so as anybody else.

Q. You have large rafts and push them or tow them down with steamboats?—A. Yes, sir.

HENRY BOSSE, having been duly sworn, testified as follows:

Examined by Mr. NELSON:

Q. Mr. Bosse, what work are you engaged in?—A. I am draftsman in this office (under Colonel King).

Q. How long have you been here?—A. I worked in St. Paul in former years for the Government for three years, and I have been here since 1878.

Q. For three years you were at St. Paul in the Government engineer's office?—A. Yes, sir.

Q. Are you acquainted with the Mississippi River from St. Paul down here?—A. I think I am; particularly through my office work, and partly through field work.

Q. You have been engaged in field work?—A. Yes, sir.

Q. In making these surveys?—A. Making surveys and examinations of improvements.

Q. Are you able to state from memory what the effect of the building of the reservoirs and the penning up of the water there has been on the navigation of the upper river?—A. My information on that comes from my official work here. During my short stay in St. Paul the fluctuation of the river was very often caused by the shutting and opening of the mills. I remember about six or seven years ago, when the water was exceedingly low, the officer in charge of the reservoirs was requested to open them, and we know that he afterwards had a raise of a foot.

Q. After he was requested to open the reservoirs and after they were opened you had a raise of over a foot?—A. Over a foot in St. Paul. Our boat was aground and we had no rainfall, and that was due to the reservoirs—they raised the river and we floated off.

Q. Your boat was aground and without any freshet or flood or rainfall the increased water from the reservoirs enabled you to get off?—A. Yes; but I had the general opinion of pilots and other river men that the effect below Lake Pepin was hardly noticeable.

Q. Well, that is accounted for by the fact that Lake Pepin is a very large and deep body of water.—A. Yes, sir.

Q. And it could hardly affect it noticeably.—A. Yes, sir.

Q. But from St. Paul to Lake Pepin it affected it?—A. Yes; because the river is so small and narrowly confined the discharge of the water would have quite an effect.

Q. And between St. Paul and Lake Pepin comes in the St. Croix River?—A. Yes, sir.

Q. And there is a good deal of navigation on the St. Croix, in the shape of logs and lumber and steamboats towing logs and lumber?—A. Yes; mostly. There is a little towage of firewood.

Q. Do you remember how far the mouth of the St. Croix is above Lake Pepin?—A. Prescott is right at the mouth of the St. Croix River. Red Wing is down about 22 miles.

Q. Red Wing is 22 miles below the mouth of the St. Croix?—A. And if you add 5 miles from Red Wing to the head of the lake——

Q. That would make it in the neighborhood of 30 miles?—A. Yes; I think so.

Q. The St. Croix River comes in, then, about half way between St. Paul and Lake Pepin?—A. That is about it; yes.

Q. You are familiar with the improvements that have been made on the Mississippi River from St. Paul to Rock Island?—A. Quite familiar there.

Q. Those works consist of riprapping, wing dams, and closing dams chiefly?—A. Yes, sir.

Q. I believe there are no levees above this point?—A. No, sir.

Q. What has been the effect of the making of these improvements upon the navigation?—A. They have undoubtedly improved the low-water channel; that is what we have been after.

Q. Those wing dams are only intended to be a little over low water?—A. We build them very low, so that the water, as soon as it raises above a favorable stage for navigation, goes over the dams and deposits in the eddy caused by the dam the material that is carried along. If you should build the dams too high there, naturally at a medium stage of water you would throw all the water into the channel and allow the river to carry this deposit along. The object of the wing dams is not only to confine the water to a narrower channel and cut out the channel, but to catch the deposit.

Q. So the wing dams serve a double purpose; they not only serve the purpose of confining the water within a narrower channel, but gather up the silt and movable stuff in the river and deposit it in the shape of bars below the dams?—A. Below, and fill up between the dams. Some of our maps here (if you take an interest in that) show a remarkable accumulation of deposit.

Q. But those dams don't extend but a little over low water?—A. Only a little over low water; we build them lower and lower, and a good many of them are built only up to low water.

Q. From what you have examined and know about the river, and the knowledge you have derived in this office, what is the effect of those dams to deepen and scour out the channel that is left?—A. That is a question that has been debated and disputed by all the river men in the Old Country as well as here. We claim that we deepen the channel. A great many claim that we raise the river bed.

Q. And simply raise the water that is on the river bottom?—A. Raise the water that is on the river bottom.

Q. That is a mooted question, then, among hydraulic engineers, whether these wing dams really deepen the channel as a matter of fact, or whether they simply improve navigation by raising the water?—A. That is it. At the same time, just as Mr. Denkmann says, we have overcome or done away with a great many places of difficult navigation there. Of course in former years, when we found a bad place in the river, with the limited means we had we just put in dams there and relieved navigation at that bad obstruction. Now, we gradually extend our system on a larger scale, because Congress has been more liberal and we can expend more money. The principal part of the river work is almost completed from St. Paul to Lake Pepin. We occasionally do a little dredging, but all the dams are in there, and most of the riprapping.

Q. You will notice these figures (Exhibit B) show, on the whole, a rather diminished stage of high water. Don't you think the effect of these river improvements that we have been talking about (reservoirs, wing dams, closing dams, and all these other works) has been to equalize the flow of water in the river? You know what I mean by equalizing it?—A. Yes, sir.

Q. And so indirectly to diminish the floods in the river and to give us on the whole lower stages of water than we had years ago?—A. I don't think so, Senator.

Q. If you take these figures and look them through, you will perceive that on the whole there has been a diminution in the high stages of the river from what it was in former times. How do you account for that?—A. The farmer has dry seasons and he has wet seasons. Why can't we have them here on the river? I remember the first ten years we were here high water was frequent in the spring as well as in the fall, and during the last ten years we have had low water and high water. I remember the first five or six years after I came to this office there was no difficulty with navigation, and the lumbermen lost all interest in our appropriations because they thought we didn't improve navigation, and there was a good deal of objection to our improvements on the part of the pilots. Then all at once we got low water for four or five years in succession, and then they realized the merits of our system and they were astonished that navigation wasn't as bad as it had been in former years, and gradually they all became converted to our idea—to our system here. But this high water or low water, Senator, depends entirely upon the rainfall.

Q. Well, to sum it up, then, you ascribe this diminished stage of water, as compared with former years, wholly to diminished rainfall?—A. That is what I think. If that diminished rainfall is caused by the cutting of timber or anything else, of course I can't say.

Q. Are you familiar with the levee system and its effect on navigation?—A. Well, not exactly. Of course, I have been in the Old Country and have seen extensive levees there.

Q. Where?—A. In Germany.

Q. On what rivers?—A. On the Elbe, for instance.

Q. On the lower Elbe?—A. Yes, sir.

Q. And the lower Rhine?—A. Well, I have been there; just passed through.

Q. From your knowledge, observation, and experience, what is the effect of the levee system, both on the question of navigation and the question of overflow?—A. I don't think it has any effect on navigation there, because in time of high water there we can navigate everywhere.

Q. And in low water the levees don't cut any figure?—A. No; not at all. Those levees in the Old Country were only built for the purpose of protecting the land. Land is more valuable there than it is here, because every square foot is under cultivation.

Q. Are you familiar with the small levees that you have built in this district?—A. I don't think so, Senator; in fact, I have never seen them, except the Sny Levee—I have seen that, walked over it—but the new levee that we have been building for the last two years I haven't seen.

Q. What, in your opinion, has been the effect of the Sny Levee? Has it had any important effect on navigation?—A. No, sir.

Q. Bettered it or improved it?—A. I doubt it.

Q. Has it had any other material effect than to reclaim that body of land there?—A. I think not. It is magnificent soil behind the levee there; one of the richest sections of farm lands that I have seen.

Q. Have you studied or investigated or thought about this matter of floods on the lower Mississippi River so that you have any opinion on that subject?—A. Well, my opinion is formed from reading and coming in contact with the question in my official work here. But considering floods as they occur occasionally, I think that depends entirely upon the rainfall.

Q. You don't think that anything man has done through there has aggravated the situation in any way, then?—A. I don't think so.

Q. You don't think the building of levees and the shutting off of great basins from the river at high water has any effect in increasing the floods or increasing the stages of water?—A. Well, it may increase the flood in the country above the levee; I should think if you cut off the high-water basin and narrow it down, that you might flood parts of the country above the levees. I never have been below St. Louis. I have no opinion on that.

Q. On the whole, then, your opinion is that these works on the upper river have done a good deal to improve navigation?—A. I think they have.

Q. And you think the reservoirs have improved navigation from St. Paul to Lake Pepin?—A. Yes, sir.

Q. Materially?—A. That is my opinion, as far as my observation goes.

Examined by Mr. BERRY:

Q. You never have done any work on the lower river, never have been employed on the river there?—A. No.

Q. And don't know anything about it, except from what you have heard and read?—A. I only judge from what I have heard and read about it.

Q. You have had no personal observation of the river from Cairo down?—A. No, sir.

SIOUX CITY, IOWA, *October 27, 1897.*

Capt. JAMES C. SANFORD, having been sworn, testified as follows:

Examined by Mr. NELSON:

Q. You are an officer in the Engineer Corps of the United States Army?—A. Yes, sir; captain.

Q. And are you operating under the Missouri River Commission?—A. No, sir; their limits terminate at the southern limit of Sioux City.

Q. And you are under the general law, from here up to Stubbs Ferry?—A. Yes, sir; under the Chief of Engineers.

Q. But you are the engineer in charge of the Missouri River from Sioux City to Stubbs Ferry, Montana?—A. Yes, sir.

Q. And any navigable tributaries connected with it?—A. The Yellowstone River, also.

Q. That is navigable, too, for a piece?—A. It is navigable. It is not now navigated, but it has been.

Q. Please state briefly what navigation of a substantial character there is on the Missouri River from here up, on what reaches of the river it is, and its extent. Going up the river, how would you divide it? Would you make one section from here to Pierre?—A. From here to Pierre I would make one section.

Q. Pierre is the capital of South Dakota?—A. Yes, sir.

Q. What is the distance by river, approximately, of the section from

Sioux City to Pierre?—A. Pierre is about 363 miles from Sioux City by the river.

Q. In that reach of the river you have how many leading tributaries on the east?—A. We have two, the Sioux and the James rivers.

Q. Are there any on the west?—A. The Niobrara River is a very important tributary on the west.

Q. That is in South Dakota?—A. It is near the line between South Dakota and Nebraska.

Q. Which is the most important of those rivers in reference to the amount of water sent down the Missouri by them?—A. The Niobrara, without doubt.

Q. The Niobrara sends the greatest amount of water at high water?—A. Yes, sir; at the average high water.

Q. What is the actual commerce or navigation on this reach of the river?—A. At the present time there are only two boats navigating from this port.

Q. Up river?—A. Up river; none below. These boats run up now, during the harvest season, to a section of the river that is remote from railroads, to the south of Chamberlain, S. Dak. About 100 miles south of Pierre a railroad comes in, and at Running Water another railroad comes in.

Q. And in that section remote from railroads they rely on the river some?—A. They either have to rely on the river or team a distance of as much as 35 miles, I think. They are hauling a great deal of this season's crop to the railroad at Running Water. Most of it is dropped at Running Water now.

Q. Two boats?—A. Two boats. At other times of the year they come down here.

Q. How much water do these boats draw?—A. They both draw light—between 2 feet and 30 inches.

Q. Can they navigate the river up to Chamberlain, at low water?—A. Yes; if they don't load the boats too heavily.

Q. They can navigate at all stages, then?—A. There is practically never less than 30 inches of water at low water. There is a steamer running out of Chamberlain now (owned by a contractor) for transporting supplies to the Indian agencies. It runs from Chamberlain to the Brule Agency, usually, I think, and hauls such freight as it can get along the way. Those are the only up-and-down boats there are now. A large boat was brought up here this spring to be used on this river, but it was wrecked against the bridge here at Sioux City.

Q. How long have you been stationed at this point?—A. A year and a quarter.

Q. Where were you stationed before you came here?—A. At St. Louis. I was with the Missouri River Commission then, secretary of the commission.

Q. Do you know anything about the character of the navigation on this river years back? Has it been for the last five or six years substantially as you have described it?—A. Well, for five or six years it has probably been about the same.

Q. Take the five years back of that; that would cover a ten-year period; wouldn't your statement cover that period, substantially?—A. In the year 1887 the Great Northern Railroad was finished, running through Montana and to Fort Benton, which was formerly the head of navigation; and, in the five years following, there were a good many boats that formerly navigated to Fort Benton——

Q. From Bismarck up, wasn't it?—A. They had been running from

Bismarck up; yes, sir; but they began to use those boats for local business along the entire river at different points.

Q. Well, take it from 1890 down?—A. Since 1890 the upper boats have pretty nearly gone.

Q. From 1890 down, it has been pretty nearly as you have described it here?—A. Yes, I should say so.

Q. Please state briefly the character or nature of the improvements that have been made on the reach of the river from Sioux City to Pierre.—A. The only general scheme of improvement that has ever been adopted for this portion of the river is the removal of snags and obstructions by snag boats.

Q. That is, removing snags or trees that have fallen into the river?—A. Yes; and rocks, even.

Q. But there has been nothing done in the shape of levees and wing dams?—A. No; not as a general scheme.

Q. No wing dams, no levees, and no riprapping to speak of, I suppose?—A. Not as a general scheme for the benefit of navigation.

Q. There has been some riprapping done at these so-called harbors (that means river fronts) opposite towns?—A. Yes, sir.

Q. But outside of that there has been no riprapping nor wing dams?—A. No.

Q. Nor anything except operating a snag boat?—A. No.

Q. Is that a Government boat?—A. Yes, sir; there are three of them altogether operated on the whole river from here up.

Q. Now, take the next reach of the river, from Pierre to Bismarck. What rivers are there in that reach of the river, on either side, that bring water of any consequence into the Missouri?—A. The Cheyenne is the largest tributary.

Q. That is on the west side?—A. That is on the west side. That drains the Black Hills. It has two forks, one running on the south side and the other on the north side of the Black Hills.

Q. Approximately how does the Cheyenne River compare with the Sioux and Jim rivers as to quantity of water?—A. In low water there is very little water coming out of it, but at high water I think it is a larger stream than the others.

Q. Brings more water into the Missouri than these other streams between here and there?—A. Yes, sir; I think it does.

Q. And in that reach of the river there is no stream on the east side?—A. No stream of any consequence. All the water on the east side goes into the Jim River.

Q. Yes; there is a divide between the Jim and the Missouri, and it either goes into one or the other?—A. Yes, sir; and it is pretty close to the Missouri.

Q. The Cheyenne starts at the Big Sioux Reservation, doesn't it?—A. It starts even back of that. It starts in Wyoming.

Q. And comes through the Black Hills?—A. One fork follows around to the south of the Black Hills, and the other to the north of them.

Q. What has been the navigation during this same period (from 1890 down to the present time) on the reach of the river from Pierre to Bismarck?—A. The navigation has been mostly from Bismarck down. Fort Yates, a military post about 75 miles below Bismarck, has always been supplied by water from Bismarck, and the supplies for Standing Rock Agency have come mostly by water.

Q. Is there more than one boat there?—A. At the present time there are two boats running there.

Q. And has that been the maximum number of recent times?—A. I don't think it has exceeded three since 1890 at any time.

Q. And the main navigation has been to supply Fort Yates and the Indian agency there?—A. Yes, sir.

Mr. BERRY. Are those private boats?

The WITNESS. They belong to the Benton Transportation Company.

Q. What class of improvements are there on the reach of the river from Pierre to Bismarck?—A. The same as there are below.

Q. That is, you have only a snag boat, no wing dams, no riprapping, except in front of harbors, and no improvements to narrow or straighten the channel in any way—nothing but the removal of snags?—A. That is all.

Q. Now from Bismarck up to Fort Benton—that is the next reach of the river, isn't it?—A. I think the mouth of the Yellowstone might be taken into consideration.

Q. Yes, that is a big stream.—A. Yes, bigger than the Missouri up there.

Q. What is the distance from Pierre to Bismarck?—A. About 277 miles.

Q. Now take the reach of the river from Bismarck to the mouth of the Yellowstone. What is the distance?—A. Three hundred and ten miles.

Q. Fort Buford is at the mouth of the Yellowstone, on the other side of the river?—A. Directly opposite; yes, sir.

Q. What has been the character of the navigation on that reach of the river since 1890?—A. The only navigation has been from Bismarck to Fort Berthold.

Q. Is that below the Yellowstone?—A. Yes, sir; it is only about 107 miles up. The same boats that ply below Bismarck have been plying on that stretch of the river also.

Q. So nearly all the navigation of those Bismarck boats has been to supply Fort Berthold above and Fort Yates below?—A. The greater part of it.

Q. Along the river, above Bismarck, it is pretty well settled, isn't it?—A. A good many settlers have gone in there, and they raise a good deal of wheat, flaxseed, etc.

Q. On the river bottoms?—A. Yes, sir; the greater part of the freight above Bismarck has been farm products.

Q. Have they been troubled with floods much up there?—A. Yes; a great deal more than we are; in the spring when the ice gorges.

Q. Is there one boat only, or two, up there?—A. Well, all these boats that ply below Bismarck—there were three this year. I understand only one is running above Bismarck now. There are two running below, as I told you. I think the whole three have been up there at one time or another this year.

Q. Is there any navigation on the Yellowstone River?—A. Not at all now.

Q. How long since it ceased?—A. Almost immediately after the completion of the Northern Pacific road, which was in 1883 or 1884, I think. I am not certain as to the year.

Q. Well, since the completion of the Northern Pacific road there has been substantially no navigation on the Yellowstone?—A. There has not.

Q. About what is the distance from the mouth of the Yellowstone to Fort Benton?—A. About 525 miles.

Q. Has there been any navigation on that reach since 1890?—A. The last steamer to Fort Benton was in 1889.

Q. Fort Benton was the old-time head of navigation?—A. Yes, sir.

Q. And the main outlet from that country before the construction of the railroads, wasn't it?—A. Yes, sir.

Q. And now from the mouth of the Yellowstone up there is no navigation at all?—A. Absolutely none.

Q. And what is that distance?—A. About 525 miles.

Q. Are you making any improvements on that reach of the river?—A. No, sir. The Government expended a great deal of money from Fort Benton down as far as Judith, which I think is about 89 miles, intending to go down about 170 miles; but that work terminated in 1891.

Q. And no work has been done since?—A. The work was abandoned because navigation stopped, and there has been nothing done since.

Q. There is a scheme pending, I understand, for the improvement of a reach of the river above Fort Benton up to what they call Stubbs Ferry. The Great Falls has always been a great obstruction to navigation, hasn't it?—A. It is an insuperable obstacle.

Q. Now, there is a reach of the river from the Great Falls to Stubbs Ferry. What is the distance there, approximately?—A. About 130 miles.

Q. You are carrying on extensive improvements there, are you not; building dams or something of the kind?—A. In half of it we are. It is divided physically into two reaches; one of them we call the Long Pool. There is where we are doing the work.

Q. That is the lower reach?—A. That is the lower reach.

Q. That is from Great Falls up?—A. To Cascade.

Q. And what is that distance?—A. Fifty-five miles.

Q. Would that be navigable if there were boats in it?—A. Yes, sir. That is the most navigable portion of the whole Missouri River without any question. The fall is less than 6 inches to the mile, there is scarcely any current, and the river there is of an entirely different character from the river below; the water is clear; it is more like a lake.

Mr. BERRY. That is from a point above the falls?

The WITNESS. Yes, sir.

Q. It is practically a sort of slack-water navigation, isn't it?—A. It is.

Q. And clear water; it is just as clear as the Upper Mississippi?—A. Yes, sir.

Q. And from that to Stubbs Ferry would be how far?—A. About 75 miles.

Q. Well, what is the character of that reach?—A. It is rocky. The slope is 3.73 feet to the mile. It is obstructed by one very heavy rapid, known as the Halfbreed Rapid, and another one known as the Beartooth Rapid, which is almost as bad, and by numerous smaller rapids and ripples, as they call them.

Q. There is a scheme pending, I understand, to improve that reach of the river?—A. Yes, sir.

Q. And there has been a good deal of money expended?—A. That is so.

Q. And the work is going on. But will it lead to any practical results?—A. The work so far has all been in this Long Pool.

Q. In the lower reach?—A. Yes, sir. It is nearly completed there.

Q. That is of value?—A. I think it is, without much question.

Q. There will be 55 miles of steamboat navigation there?—A. Yes, sir.

Q. But for the 75 miles above that, is there ever likely to be any

practical use of that for purposes of navigation?—A. I have doubts about it.

Q. What is the proposed cost for the project above that, for the upper reach?—A. $165,812, from Great Falls to Stubbs Ferry.

Q. And how much has been expended?—A. It is almost equally divided between the two reaches; there will have been expended, as soon as the present appropriation is expended, $51,000.

Q. On the lower reach?—A. On the lower reach.

Q. And how much has been expended on the upper reach?—A. None under the present project; in 1880 there was some work done up there——

Q. You haven't done any work on the present project, then, since 1880, on the upper reach?—A. No, sir; the present project dates back only to 1894.

Q. And that includes simply the lower reach?—A. The work done covers only the lower reach, but the present project includes both reaches.

Q. But you haven't done anything above?—A. No, sir.

Q. Well, don't you think the expenditure of money above there will be, comparatively speaking, useless; that is, that there will be no real equivalent in the shape of navigation to be derived from the expenditure of money above that point?—A. That is a question I have been thinking about a good deal. I intend in the spring to go over that whole reach and find out more definitely about it.

Q. As I understand you, the fall in that whole distance is how much?—A. 3.73 feet.

Q. About 3¾ feet?—A. Yes, sir.

Q. To the mile?—A. Yes, sir.

Q. And there are several rapids?—A. Yes.

Q. The river passes through a rocky formation, doesn't it—a great deal of rock and stones?—A. Yes; and mountains.

Q. And there are a great many bowlders and rocks in the river?—A. Yes, sir.

Q. And you would have to do a good deal of blasting, would you, to make the channel navigable—a good deal of rock work, I mean?—A. I think the most of it would be in the removal of bowlders and in the confining of the water to one channel.

Q. There are no boats plying on that reach above Great Falls, are there?—A. In the Long Pool there are three boats.

Q. How long have they been plying?—A. One of them dates back to about 1890, the other two have been built since; one was built a year ago.

Q. Is there much traffic on that reach of the river?—A. There is a good deal of wood and hay brought down for the local market at Great Falls; that is a town of perhaps 12,000 people. It is a thriving town, and has the best water power in the United States.

Q. I presume they have from eight to ten thousand people there; say 8,000 for sure?—A. Perhaps that would be fairer.

Q. Really, then, from the mouth of the Yellowstone to Great Falls, a distance of over 500 miles, there has been no navigation since 1890; there is a little navigation above the Great Falls on this reach of 55 miles?—A. Yes, sir.

Q. But beyond that nothing has been really done except a survey and estimate, and it is a problem, to say the least, whether any value received can be obtained from the improvement of the upper reach?—A. Yes, sir. The thing principally urged there is that it would make

a wonderful scenic route for people going to the Yellowstone Park over the Northern Pacific and wishing to return by the Great Northern. They could go through what is known as the White Rock canyon, one of the most wonderful canyons in the country. The scenery is grand.

Q. Stubbs Ferry is near Helena, is it not?—A. Yes, sir.

Q. How far?—A. About 12 miles.

Q. Commencing with the upper river and running down, are there any good retaining grounds where you could build large reservoirs that would pen up and hold back large quantities of water during high water, for the purpose of irrigation and improving navigation and also restraining or checking floods on the Lower Mississippi?—A. Yes, sir; there are some wonderfully well-adapted places for just that thing.

Q. At what points?—A. They are all above Great Falls.

Q. Could a reservoir be made between Fort Benton and the Falls?—A. No. But at the Three Forks, where the Missouri River is formed, reservoirs could be built.

Q. Where is that—above Stubbs Ferry?—A. Yes, sir; about 136 miles above Stubbs Ferry.

Q. Right there you could build a reservoir?—A. You could build a reservoir where the Gallatin, Jefferson, and Madison rivers unite to form the Missouri. That reservoir probably would not be available for irrigation purposes except right in this valley itself.

Q. Could that reservoir be built at a limited expense, or would it be costly?—A. The dam itself would not be costly, but a good deal of the land in that section is irrigated now and produces wonderful crops, and that land would be overflowed.

Q. You would flood a good deal of land, would you?—A. You would flood that whole valley.

Q. And that is about all there is in that country, isn't it?—A. Well, that is the best portion of it right around there.

Q. And isn't it a fact that it is so remote from the lower river that it couldn't cut very much of a figure in restraining the floods?—A. Probably so. But this is the first good place for a reservoir.

Q. But it wouldn't amount to very much for irrigation purposes, because in order to get a good reservoir you would have to destroy all the lands that are worth anything?—A. Yes; it probably wouldn't amount to a great deal as an irrigating proposition.

Q. And it is really too far up the river to make it of much account as a holding ground to restrain floods?—A. Yes; that is probably true.

Q. Is there any place near Great Falls where a large reservoir could be built?—A. A reservoir could be built in this region; [indicating on a map land westerly and northerly from Great Falls].

Q. Would that flood much valuable land?—A. It would if a high dam were built. But as an irrigation proposition it is not necessary to flood much land here.

Q. As a matter of irrigation it is of no particular consequence?—A. It is in this way [indicating toward Havre, on the Great Northern Railway]: Up to the Milk River the divide is very low. Here [indicating about the Marias River] the Great Northern is on a level with the Missouri, and there is probably only a few hundred feet of rise over here [pointing]. Now, you get a height of 512 feet above the falls. That water could be carried over on a proper slope, at a considerable height above the level of the Milk River, and allowed to run into the valley and back into the Missouri.

Q. A great reservoir could be built at or above the falls, which would make that whole 55-mile reach of the river a big holding ground,

and it could be held so high that the water could be taken over into the Milk River?—A. Yes, sir.

Q. You are sure that a good reservoir could be built at or above Great Falls, from which water could be diverted into the Milk River Valley and furnish irrigation for that valley and also some irrigation for a part of the Missouri Valley below the Great Falls?—A. Yes, sir; perhaps. That would have to be determined by a careful survey.

Q. Have you any idea of the approximate distance from the point at which you would connect the waters of this reservoir with the Milk River, down to the mouth of the Milk River?—A. About 170 miles.

Examined by Mr. BERRY:

Q. Does the Milk River empty into the Missouri?—A. Yes, sir; it is one of the largest tributaries above the Yellowstone.

Q. Would that have the effect of interfering with the navigation of the river anywhere below—here at Sioux City, for instance?

Mr. NELSON. No; the water goes back into the Missouri, doesn't it?

The WITNESS. Some of it does, but of course a great deal of it evaporates. It would, of course, lessen the amount of water down here during the time it is used for irrigation; but the time irrigation is necessary doesn't extend further than the first part of August in each year, and the river isn't at a low stage until long after that time. The canal would naturally be closed and all the water thrown into the river after August, because there would be no need of it for irrigation?

Q. Where does the Milk River flow into the Missouri?—A. About 177 miles above the mouth of the Yellowstone.

Examined by Mr. GALLINGER:

Q. Captain, if that reservoir which you have described as practicable at or near Great Falls should be built, would great damage from flowage ensue?—A. The land at present is worth very little; it is occupied mostly for sheep ranges. A little natural wild hay is cut on it, but there is practically no cultivation on account of the dryness.

Q. Would a large area be overflowed?—A. An area about 55 miles long, river distance, and of course of varying widths, at no place very wide; perhaps a mile and a half would cover it.

Q. Could you state approximately how much that reservoir would contain?—A. I could not very well, for the reason that it would depend on the height of the dam necessary to get the water up to a level from which it could be carried off by a canal of practicable cost.

Q. Do you believe it would hold sufficient water to make it of any special value below that point, so far as the interests of commerce are concerned?—A. By letting it out to increase depths during low water?

Q. Yes; that is my idea.—A. No, sir; I don't. It would simply provide irrigation for a section of very fertile land 170 miles and perhaps more in length, and 2 or more miles wide.

Q. In other words, if the Government should commit itself to the idea of irrigating the lands of individuals, it could be utilized advantageously for that purpose?—A. It is practically all Government land now. Yes; it could be utilized for that purpose.

Mr. NELSON. Most of the Milk River Valley is Government land, isn't it?

The WITNESS. Almost all.

Mr. GALLINGER. And the Government could improve its own land in that way and sell it for an advanced price; that is your idea, is it?

A. It could do it. I think in time that land will be worth a great deal of money.

Mr. NELSON. The Government in time could do what other parties do; it could sell the land to settlers and sell water rights, as they do in California.

Mr. GALLINGER. Of course, the Government never enters into that kind of business. It would be a new departure, wouldn't it?

The WITNESS. Yes. Senator, there is a company now that is very anxious to get hold of that thing. They tell me the difficulty with them is that according to present laws they can't get a large enough tract of land in their own name. The only way they can do is to take up land under the desert-land act and have settlers take land and turn it over to them when they get title.

Mr. NELSON. You mean there is a company that, if they could cooper all the land in the valley, would go in and build up this reservoir and irrigate in the way you indicate?

A. Well, I don't know that they would do it in the way I have indicated, but they would irrigate the Milk River Valley. Of course, the Milk River itself might be used for that purpose to a certain extent, but it hasn't water enough to irrigate a great deal properly. But there is an abundant discharge of water at Great Falls—more than is discharged by the Mississippi at St. Paul or the Ohio at Pittsburg.

Q. Well, Captain, in short, your view is that the value of a reservoir at that point would necessarily be confined to purposes of irrigation; that is it, is it?—A. Yes, sir.

Examined by Mr. BERRY:

Q. You don't think water could be held in sufficient quantities to increase the flow down below here in time of low water to any appreciable extent?—A. No, sir; I do not.

Q. Or to diminish it in time of flood to any appreciable extent?—A. Not down here; no, sir; the valley is too wide.

Examined by Mr. NELSON:

Q. Coming down the river, what other points are there, if any, where there are good holding grounds or good places for reservoirs at or near the mouth of the Cheyenne River? Could there not be constructed on the Cheyenne quite a considerable reservoir?—A. I have never been in that section of the country. I don't know how that is. I have been past the mouth of the Cheyenne, on the Missouri River, and I don't think you could construct one very near the mouth; but there might be some place above the mouth where reservoirs could be constructed. That would have to be determined. There may also be places in the Missouri below Fort Benton.

Q. I want to call your attention to the reach of the river from the mouth of the Cheyenne up to what I would call the bend of the Missouri here [pointing on a map]. Wouldn't it be feasible and practicable to make a large reservoir either at the mouth of the Cheyenne River or somewhere in the Missouri bottoms here, by which you could get a big supply of water to irrigate the country below? Did you ever think of that?—A. Well, I have thought about it in the Missouri itself. The expense there would be something absolutely awful—in the Missouri River.

Q. Could a reservoir be made anywhere in the Missouri River between Yankton and Bismarck, either in the Missouri River itself, by damming up its bottoms, or in the Cheyenne or White rivers, that would give ample water for irrigation purposes in the country south of it, in the States of South Dakota, Nebraska, Kansas, and south of there?—A.

This whole country is about on a level with the tops of the bluffs, and to get water over it would require a dam of great height.

Q. You would require a dam as high as the bluffs, wouldn't you, to irrigate there?—A. Yes, sir; and before you could determine about it you would also have to take levels to see if you could get a proper slope for an irrigation canal.

Q. You don't think it is feasible, then, to get any reservoir of any consequence for irrigation purposes, or navigation or flowage purposes, at any point between Yankton and Bismarck?—A. No, sir; I don't think you could in the Missouri.

Q. Or in any of its tributaries?—A. That I don't know anything about.

Q. The only tributaries of any consequence on that reach would be the Jim River and the Cheyenne River and the White River?—A. Yes, and all of those streams run through alluvial soil, which is in general very deep before you get down to a good foundation. Occasionally you strike a ledge of rock as you do above here on the Big Sioux. But where you are working in that sandy country (and the valleys are usually pretty wide) the cost of a dam would be something very great, and the height of the plateaus between the rivers is usually considerable and rather slopes back from the river bluffs, if anything, and doesn't lie well for irrigation purposes; it is a broken, chopped-up kind of a country, rolling, and contains lake beds.

Q. From Yankton down here (Sioux City) are there any places where reservoirs could be built to promote navigation or to materially affect the overflow of the river below?—A. No, sir; not at any practicable cost. This is the worst section of the river, because the valley is much wider here than anywhere else.

Q. Really, then, in your opinion, the only place where a reservoir could be built that would be useful to any material extent would be at or above Great Falls, in the reach of the river that you speak of?—A. Probably. The reach between Fort Benton and the Milk River I have never seen; it is rocky, with considerable slope, and the valley is very narrow.

Q. Isn't it possible that a survey might develop the fact that a great irrigating reservoir could be built somewhere between Yankton and Bismarck, from which an irrigating ditch could be led down through South Dakota, Nebraska, Kansas, and on through that semiarid belt? In other words, couldn't you divert the Missouri River down through that section, by means of a dam, at high water?—A. It would be a terribly expensive undertaking, sir, because you would meet some of the tributaries of the Missouri and you would have to aqueduct across the valleys.

Q. It is hard to tell without taking levels about that?—A. You couldn't tell anything about it. It is possible that at the head waters of the Cheyenne and some of these other rivers there might be opportunities of that kind.

Q. Couldn't a reservoir be built at the head of the James River?—A. That is a very flat country. You could build a reservoir there, undoubtedly, and cover an immense territory with it.

Q. And the Sioux River?—A. The Sioux is about the same way, but you couldn't get much irrigation out of it, because the slope of the James River is so gentle. By damming it up you could cover the back country, but the water wouldn't be much above the valley below.

Q. Now, at certain places where the bank is caving in in front of cities, you are making some improvements known as harbor improvements. At what places are those?—A. Sioux City is the first one.

Q. You have an appropriation for that?—A. Yes, sir.

Q. Is the bank caving here?—A. We have had two appropriations; one for across the river, where the bank has been caving and where we have protected it by revetment, consisting of a willow mattress under water and a sloping bank paved with rock on top.

Q. And what is the other?—A. On this side of the river the river is cutting badly at the lower part of the city front. There, on account of property interests, it is important to hold the river off. We can't slope the bank, because there is a railroad track on top and almost on the edge of it. There we are putting in a system of dikes around on the curve and running the river out so it can't undermine the bank.

Mr. BERRY. What is the object of that, Captain?

A. That is to prevent the further undermining and caving of the bank at the lower part of the city.

Mr. BERRY. It has nothing to do with commerce in any way, has it?

A. No, sir.

Q. I suppose nothing more than to afford a steamboat landing?—A. Well, it holds the bank in one place; it makes a permanent landing.

Q. We made an appropriation last year for improvements at a point above here—Elk Point. Have you done anything about that?—A. No, sir; except to make a survey and project for the improvement. It was decided by the Secretary of War that the money should be reserved until Congress by further appropriation should furnish enough to make the improvements with safety. It was considered too small a sum to complete the work.

Q. What is needed there?—A. There the bank is caving badly.

Q. Under the town—undermining it?—A. It is well away from the town—over a mile and a half from town.

Q. Is there any danger of it undermining the town?—A. Not for a long time. It is working that way slowly.

Q. Is the place where the water is working at a point where the steamboat landing is?—A. There is no steamboat landing or steamboat commerce there.

Mr. GALLINGER. So the proposed improvement at Elk Point is not for the purpose of improving the navigation of the river, is it?

A. No, sir; navigation interests are not concerned at all.

Q. The next point is Yankton?—A. Yes, sir.

Q. Is that work done, or is it pending?—A. It is being done.

Q. State what the nature of the work is, please.—A. A sand bar had formed in front of Yankton which had destroyed the old steamboat landing, where the warehouses and railroad tracks were, and it had built out quite a distance in front of town and was shifting and changing continually. We are improving the river from a point about 5 miles above Yankton to a distance below the town, with a view to holding the channel through the railroad bridge above Yankton and restoring and maintaining the old steamboat landing.

Q. That would really restore the old steamboat landing?—A. Yes; part of it would.

Q. And that is indirectly in aid of navigation?—A. Yes, sir.

Q. It is to restore the steamboat landing that once was up to town, and to keep it there; isn't that it?—A. Yes, sir.

Q. What was the appropriation, Captain, for Elk Point?—A. $20,000.

Q. And for Yankton, how much?—A. $40,000. Perhaps you remember (I don't know that your attention has been called to it) the appropriation was peculiarly worded: For improving the Upper Missouri, $220,000, of which, in the discretion of the Secretary of War, $50,000

might be expended in the protection and completion of the works at Sioux City, $50,000 for the protection of a caving bank on the South Sioux City front, $50,000 at Pierre and Fort Pierre, $40,000 at Yankton, $20,000 at Elk Point, $40,000 at Bismarck, $20,000 between Great Falls and Stubbs Ferry. Those amounts aggregated $270,000, so the Secretary of War decided they would all have to be scaled down, and they were all scaled down, except at Elk Point, $20,000.

Q. That was a specific amount?—A. Yes; but that wasn't scaled, like the others.

Q. Now, above Yankton, what is the next? Any at Pierre or Chamberlain?—A. Pierre is the next one.

Q. Nothing at Chamberlain?—A. No, sir.

Q. Is the work at Pierre done or pending?—A. The work at Pierre has been going on since 1895. There was a former appropriation for Pierre. That consists of rectifying the river for a reach of about 7 miles.

Q. Opposite the town?—A. Opposite the town; yes, sir.

Q. To give them a better steamboat landing, or what?—A. It is to hold the steamboat landing where it is, and to prevent the river below the steamboat landing from cutting into the town site. The same way at Fort Pierre, across the river.

Q. What is the appropriation for that harbor?—A. That was $50,000, scaled to $40,000.

Q. Now, the next?—A. The next is Bismarck.

Q. There have been two appropriations for that?—A. Yes, sir. Forty thousand dollars was the former appropriation, and this was $40,000, scaled to $32,000.

Q. Has anything been done there?—A. They have nearly finished the work there.

Q. What is that?—A. The former work consisted of a series of dikes in a bend where the river had cut in very savagely, and was threatening to make a cut-off into the Heart River and leave the Northern Pacific Bridge about 3 miles inland, and that was improved by a series of seven dikes, restoring the old shore line.

Q. Restoring the old shore line above Bismarck?—A. Above Bismarck, on the other side; yes. Last spring that system was very badly damaged by a tremendous break-up of ice, almost unprecedented; the river rose high, and the ice knocked out a good deal of that pile work, so a great deal of this appropriation has had to be expended in repairing those. Then below that, one dike has been built to hold the river out on the line of our proposed rectification.

Q. Is it on the west side?—A. All on the west side. Then just below the railroad bridge, the old steamboat landing has been straightened out and protected by two little dikes and 500 feet of bank protection—revetment.

Q. What is this work? Is it riprapping, or is it revetment work?—A. It is revetment work.

Q. The same as the other; mattress under water and rock on top?—A. Yes, sir.

Q. And the first appropriation was $40,000 and the other was $40,000 scaled to $32,000, a total of $72,000. How much has been expended, about?—A. Nearly all of it. A little balance is held for repairs in the spring.

Q. Is any more needed for that?—A. The project for the improvement of that whole reach calls for $725,000, I think.

Q. You mean the whole reach from——A. Bismarck; 5 miles above and 5 miles below.

Q. From 5 miles above Bismarck to 5 miles below Bismarck—the project calls for $750,000?—A. $725,000, I think it is. It is the largest scheme on the river—most costly.

Q. Would that scheme materially improve navigation? Is it necessary to go into any such extensive expenditure of money to improve navigation or give them proper harbor facilities?—A. I think about half of that amount can be dispensed with. The 5 miles below Bismarck is a very bad reach for navigation, but no worse than some other reaches between towns and a long way off from town. I think it could be cut about in two. I stated so in my annual report.

Q. Are there any so called harbor improvements above Bismarck?—A. Not on the Missouri.

Q. Is there on the Yellowstone?—A. There was $10,000 appropriated for improvements at Glendive.

Q. Well, there is no navigation there?—A. There is no navigation there. There is a little prospect of some.

Q. What is the plan at Glendive?—A. To protect the bank in front of the town where the old steamboat landing was.

Q. To preserve the steamboat landing in front of the town; has there been a project made for that?—A. Yes; the work is finished.

Q. Is there nothing further to do?—A. I think not.

Q. Do you think of anything about the river that we have not called your attention to that you think would be of value to us to know? If so, please give it to us.—A. Well, more a summary than anything else. The most important work on the whole river, in my opinion, is the work of snagging, so far as the interests of navigation are concerned.

Q. That is about all you can do unless you go into the millions and billions?—A. Yes.

Q. Unless you should go into the billions of dollars that is about all you can do?—A. Yes; of course, the work done at all of these local points is so planned that it can form a part of the general scheme if it is ever adopted. In regard to these snag boats, we have three to maintain and patrol the whole river that is now navigable from here up, and it costs about $50,000 annually to operate them. The river is continually shifting and uncovering snags and sand bars and bringing in whole forests as it cuts into the banks.

Q. Cuts down trees and lands them in the river?—A. Yes; and to keep it clear of snags we require about $50,000 every year.

Q. The bed of the river here is through a soft alluvial soil and is continually shifting from one side to the other?—A. Yes, sir.

Q. And undermining patches of timber from time to time on either side of the bank and bringing them into the river?—A. Yes, sir.

Q. And a good deal of your work with a snag boat is taking care of that timber that has worked in in that way, isn't it?—A. Yes; and keeping them out. It is very dangerous, of course, for steamboats; it has to be constantly patrolled; there is no end to it until the river is controlled and held in place.

Examined by Mr. GALLINGER:

Q. Are these buried forests old forests?—A. Yes; some of them. We find old snags, timber that has been thrown into the river in some prehistoric time and the branches all ground off by ice. They will be covered by sand by the river shifting, and then in the course of time

it will come back and uncover them; they are held down by their roots and form a very dangerous obstruction.

Examined by Mr. BERRY:

Q. You stated that there is much less steamboating on the river now than formerly. Is there less water in the river than there was in the early days, during low-water times, and is it more difficult to navigate it now than it was in former times, or not?—A. I should say not; we haven't anything to prove that it is any less.

Q. Nothing to prove that there has been any diminution of the water in any way?—A. No.

Q. Then you attribute the decreased commerce to the railroads that have been built?—A. Yes, sir.

Q. You think the upper part of the river here can navigate boats as well now as it ever could?—A. I think so; yes, sir. It used to take a long time to make trips to Fort Benton, but they got a very high rate for carrying freight and they could pay for the boat in one trip.

Q. You really think there is no diminution in the quantity of water that comes down?—A. I don't think there is.

Q. Do you think the floods are higher than they were?—A. No, sir.

Q. You don't think the clearing up of the country has tended to increase the flood tide?—A. Well, this country has had very little timber on it. The principal timber has been right close to the river on the bottoms, and most of that is there now.

Examined by Mr. GALLINGER:

Q. As I understood it, Captain, you said there are two boats running between Sioux City and Chamberlain, and that their chief business is the carrying of agricultural products.—A. Yes, sir.

Q. Suppose those boats were not plying on the river, what facilities would the farmers there have for getting their products to market? They would have to do long teaming, would they?—A. Unless they had river transportation they would have to haul their products a maximum distance of 30-odd miles, or thereabouts, to market.

Examined by Mr. NELSON:

Q. Are there any reaches of the river above Sioux City where land of any consequence, occupied and used by farmers, is overflowed at high water?—A. I think not, except in an extraordinary year, when ice gorges form.

Q. As a general rule they are not flooded?—A. No, sir.

Q. So really, as a whole, no material damage has been done to the agricultural interests by floods above Sioux City?—A. No, except at the times I speak of.

MISSOURI RIVER COMMISSION.

Q. You have stated, Captain, that you were secretary of the Missouri River Commission.—A. Yes, sir; about six years.

Q. From what time to what time?—A. From March 31, 1890, to June, 1894; from then until the end of September, 1894, I was relieved temporarily to go to Memphis; and from that time until the end of July, 1896.

Q. Last summer what were your duties?—A. I had charge of surveys and gauging of the river, collecting physical data, and things of that kind, and was in charge of the St. Louis office—that is to say, I had the hiring and paying of the employees.

Q. Sort of secretary and bookkeeper of the commission, I suppose?—A. Yes, sir. For the last two or three years I have done some outside work.

Q. That commission is composed of whom?—A. It is composed of five members.

Q. Who is at the head of it?—A. Lieut. Col. Amos Stickney.

Q. Of the Regular Army?—A. Yes, sir.

Q. He is president now, and was during all the time you were secretary?—A. No, sir; he has been president only since December, 1895.

Q. Who was president before that time?—A. Col. Charles R. Sutre.

Q. Of the Regular Army?—A. Yes, sir.

Q. Who are the other members of the commission now?—A. The law of July 5, 1884, requires that the commission shall be composed of five members, three of whom shall be members of the Engineer Corps of the Army, and the other two shall be civilians, and one of those two shall be a civil engineer. There have been so many changes in the last few months that I can't give you all of the members of the commission at this time.

Q. Well, I don't care about names. Aside from Colonel Stickney, there are two other engineers of the Regular Army?—A. Yes, sir.

Q. The compensation of Colonel Stickney and these two assistants is simply their salary as officers of the Army, is it not, and their actual expenses?—A. Yes, sir.

Q. There are two other members not of the Army?—A. Yes, sir.

Q. One of whom is required to be a civil engineer?—A. Yes, sir.

Q. What is their compensation?—A. $2,500 per year and expenses.

Q. Each of them?—A. Yes, sir.

Q. One is what you might call wholly nonexpert?—A. Yes, sir.

Q. And the other is supposed to be a civil expert as distinguished from an army expert?—A. Yes.

Q. That commission had charge of the Missouri River from its mouth to Sioux City, did it not?—A. They did after September 19, 1890. Up to that time they had charge of the entire river.

Q. What is the distance, in round figures, from the mouth of the Missouri to Sioux City?—A. About 800 miles by river.

Q. Into what reaches would you naturally divide the Missouri River from its mouth to Sioux City?—A. Into two reaches; St. Louis to Kansas City, and Kansas City to Sioux City.

Q. Take the reach from Sioux City to Kansas City, what are the principal tributaries?—A. The largest tributary is the Platte River.

Q. Coming from the west?—A. From the west. It has very little water at low water, but considerable at high water.

Q. It is quite a stream at high water, but is almost dry at other seasons?—A. Yes.

Q. Are there any others coming from the west of any consequence?—A. There is the Kansas or Kaw River; and then there are smaller ones—the Nemaha River, in Nebraska; that is the only one of any consequence.

Q. Now take the east side.—A. There is the Little Sioux, 30 or 40 miles south from here; and then there is the Grand River, away down in Missouri, flowing into the Missouri at Brunswick. Those two are the largest ones.

Q. Do any of these streams produce great floods? I mean floods that materially increase or increase to a large extent the volume of the Missouri River.—A. Not so much above Kansas City, although the Platte does send out a good deal of water when there have been heavy snows in the mountains. The rivers below Kansas City are different.

Q. Well, I want to finish the reach from Kansas City up here first. Since the time you became secretary of the Missouri River Commission, of course you have kept run of things here and know in a general way about it. Now, what has been the navigation of the Missouri River from Kansas City to Sioux City?—A. You might say there has been absolutely no navigation—it is pretty close to it—between Kansas City and Sioux City.

Q. Since you have been secretary of the commission?—A. What there has been has been very intermittent, but there has been very little.

Q. What work has the Missouri River Commission done on the river during that period, from Kansas City to Sioux City?—A. It has all been local work. They have done work at Atchison, at Leavenworth——

Q. Their chief work has been in so-called harbor improvements, hasn't it?—A. Yes, sir.

Q. That is, improving landings in front of towns?—A. Yes, sir.

Q. That is really the only work they have done, isn't it?—A. Above Kansas City.

Q. There hasn't been occasion for much snagging, has there?—A. There has been no snagging until this year. This year the snag boat came up as far as St. Joseph.

Q. The snag boats on the Missouri River haven't been in the habit of coming up farther than Kansas City, have they?—A. Ordinarily not.

Q. As a matter of fact, this reach of the river has been ignored, beyond these little harbor improvements?—A. Yes, sir.

Q. Now what are the harbors that have been improved?—A. Since 1884 or since 1890?

Q. Since you became secretary of the commission.—A. Omaha.

Q. That is about how far below Sioux City?—A. One hundred miles by rail; about 155 miles by water.

Q. What has been the character and purpose of the work at Omaha?—A. It has been the protection of a large bend just above Council Bluffs.

Q. On the opposite side of the river from Omaha, above Council Bluffs?—A. It has been the protection of property there.

Q. Private property?—A. Yes.

Q. Has it been of any use in the nature of aiding navigation or improving their steamboat-landing facilities?—A. No, sir; it has been in the country outside of the towns; railroad property up there was threatened.

Q. It has been mainly for the purpose of protecting railroad property from being undermined by the river, hasn't it?—A. Yes.

Q. Do you know how much has been appropriated for that?—A. No, sir.

Q. Where the Union Pacific crosses it owns that bridge, doesn't it?—A. Yes, sir.

Q. And the main improvements have been to protect that bridge, have they not?—A. No; it is above the bridge considerably.

Q. Well, wasn't it indirectly to protect that bridge, or was it simply to protect lands above from being undermined?—A. It was to protect lands above that form a part of the town site of Council Bluffs and over which there were one or two lines of railroad.

Q. And the railroads wanted that for their protection?—A. The holding of that bend, though, also protected the city front of Omaha in this way, that if it cut in there much deeper it would have changed the Omaha river front.

Q. Was this revetment work?—A. Yes, sir; almost altogether.

Q. Willow mattresses under water, and rock?—A. Yes, sir.

Q. Do you remember the amount expended at Omaha, approximately?—A. I suppose they have spent altogether $400,000 there, approximately.

Q. What is the next place below where they have made harbor improvements?—A. St. Joseph.

Q. How far below Omaha is that, in round numbers?—A. About 100 miles by water above Kansas City; about 200 miles from Omaha.

Q. What has been the character of the work there and the object and purpose of it?—A. There are two different places where they have worked at St. Joseph. The whole object and purpose of it all, though, was to hold the river in its channel as it existed for a number of miles above St. Joseph, and to prevent a threatened cut-off opposite St. Joseph, which would have left the city away from the river.

Q. It was to keep the city on the river bank, wasn't it, really?—A. Practically; yes, sir.

Q. Was that the same kind of revetment work?—A. Revetment and dike work.

Q. About how much has been expended there?—A. I should say approximately the same amount as at Omaha.

Q. The next is Kansas City, isn't it?—A. No; there are two small works between. Atchison is the next work.

Q. That is in Kansas?—A. In Kansas. The work was done on the Missouri side.

Q. What was the object and purpose of that?—A. At Atchison a cut-off had occurred above the town, and it changed the direction of the current; it attacked the bank opposite Atchison and cut in very deep; it had cut out two railroads and highways and a great deal of valuable improvements; some houses had gone into the river and a good many others had to be moved away, and it was cutting into the town of East Atchison—had cut into it to a considerable extent.

Q. And the purpose of this improvement was to stop that undermining and retain the channel up to Atchison?—A. Yes, sir.

Q. And was the work of the same character as at these other places—dike and revetment work?—A. Dike work before 1890, and revetment work since.

Q. What do you mean by a dike? Is it a sort of a wing dam?—A. It is an open wing dam built of piling.

Mr. BERRY. The purpose of it is to turn the current?

A. Yes, sir; and to cause a deposit between the piles. Piles are driven close together and are expected to cause a deposit of the sand—the piles and poles that are stuck down between them.

Mr. NELSON. What is the next harbor below?

A. Leavenworth. There the river was also threatening to make a cut-off and it was to hold it in its old position.

Q. What was the amount expended at Atchison, as near as you can tell?—A. I think it was $35,000 since 1890.

Q. And what at Leavenworth?—A. Not more than that; I think less.

Q. What is the distance between Atchison and Leavenworth?—A. About 20 miles by railroad; about 25 or 28 by river.

Q. The next harbor is Kansas City?—A. Yes, sir.

Q. What has been done there?—A. That is the place that the commission, when it was first organized, determined to make the head of their first reach of improvement, and systematically improve the river and control it from Kansas City to St. Louis. The work that has been done there has all been done with that object in view.

Q. What is the character of it? Is it harbor work?—A. It would hardly be called harbor work. It is being done on a general plan to confine the river to a width of about 1,000 feet by dikes.

Q. Well, it is wing dams and closing dams and riprapping, then?—A. Yes, sir.

Q. The same as on the Mississippi River?—A. Yes, sir.

Q. What is the distance from St. Louis to Kansas City?—A. About 400 miles.

Q. What is the character of the work that has been carried on by the Missouri River Commission on that reach of the river since you became acquainted with it?—A. So far as they have been able to, they have worked on this systematic plan, starting at the head of that reach and confining the river to about 1,000 feet, say, increasing as it goes down.

Q. By wing dams?—A. Yes, sir; building out the shores and making a canal, you might say, of it; a permanent deep channel.

Q. Riprapping in some places?—A. Yes, sir.

Q. These wing dams have been built of willows?—A. The wing dams have been built of piling and screening.

Q. Not like the upper Mississippi at all?—A. No, sir.

Q. Tell us in what reaches of the river they have carried on this work mostly.—A. They worked on the Kansas City end for a considerable number of years, until the people near the lower end of the reach began to feel that the work would never get down to them, and a very strong and successful effort was made to compel them to work at the lower end of the river. The law of 1892, I think it was, said that the work should be done systematically from the mouth of the river up, in reaches to be designated by the Missouri River Commission. They went to work and divided the river from St. Louis to Kansas City into three reaches, and began work at the head of the first reach, which was just above Jefferson City.

Q. From there up to Kansas City?—A. From there down to the mouths. They were working down.

Q. From Jefferson City to the mouth?—A. Yes, sir.

Q. Have they built many wing dams there?—A. Yes, sir; at the time I was relieved they had covered about 45 miles of the river.

Q. And they have been at it ever since?—A. As far as appropriations would permit them, I have no doubt they have, but the appropriations have been rather small.

Q. Is that work done by contract?—A. No; by hired labor. The Government owns the plant.

Q. What does their plant consist of?—A. Of towboats, pile drivers, hydraulic graders, mattress boats or barges for hauling material, a few machine boats for repairs, quarter boats for men, small skiffs, and such things as that. They have no dredge boats.

Q. There is no dredging done on the river, then?—A. No.

Q. They have one or two snag boats, haven't they?—A. One snag boat, a large one.

Q. And the rest of these other boats you have described?—A. Yes, sir.

Q. Well, they have done nothing, then, on the middle reach, so far, above Jefferson City?—A. They did in the early days, but while I was with them they did nothing there. During the past year they may have done some work there.

Q. Has there been any so-called harbor work done between Kansas City and the mouth of the river?—A. A little was being completed

when I came there in 1890, at Miami; after that there was none done until this last year, when they made appropriations for a number of places.

Q. Do all the commissioners stay permanently at St. Louis?—A. No, sir; Colonel Stickney is the only one supposed to stay there permanently.

Q. He stays there permanently—has an office there?—A. Yes, sir.

Q. How often do the other commissioners come there?—A. They come when the president calls a meeting, which may average three times a year, perhaps.

Q. The other members of the commission meet there about three times a year, and the rest of the time they are away. How long do those meetings last generally?—A. All the way from one day to, perhaps, eight. The long meetings are when they go on a boat to inspect the river.

Q. When they go up and down the river on a trip, they go once a year, don't they?—A. They usually try to; it isn't very regular.

Q. And aside from that they only meet one or two days in the year?—A. Four or five days would probably cover it.

Q. Outside of this steamboat trip, and that would be about a week, wouldn't it?—A. Yes; about a week.

Q. So the entire time the other commissioners are actually present and attending to work is not to exceed, say, fifteen or twenty days in the course of the year?—A. No, sir.

Q. And isn't the work they do of a perfunctory character, mainly? Isn't the work really carried on by the head of the commission and his force in the office, from your observation?—A. I think about 95 per cent of it is; yes, sir.

Q. Do those men get mileage in addition to their salaries?—A. They get their actual expenses.

Q. Whatever it costs them to get to those meetings they are paid in addition to their salaries?—A. You refer to the civilians?

Q. Yes.—A. The army officers get mileage.

Q. And of course their regular pay?—A. Yes, sir.

Q. Is there any reason why the president of that commission, the army engineer, whoever he may be, could not manage that work as well as an engineer can manage this reach of the river, in your opinion?—A. Under present conditions I don't see any reason why he couldn't manage it just as well. At the time the commission was organized it was thought that a large general plan would be formed for the improvement of the whole river, in the interests of navigation, and a large sum would be appropriated each year, and I presume it was the thought of Congress that the wisdom of five or six men was much greater than that of one. But the way it has turned out, and the way they have been making appropriations——

Q. That general scheme of improvement the commission was supposed to enter upon (to improve the navigation of the river in a substantial manner) has never been entered upon, has it?—A. Yes; they have entered upon it. They first entered upon it at Kansas City, and then removed to Jefferson City——

Q. That little wing-dam business?—A. Yes.

Q. But beyond that they have done nothing up this way?—A. No, sir.

Q. Then, with half the distance of the river committed to their charge, they have practically done nothing, except a little harbor work?—A. No, sir.

Examined by Mr. BERRY:

Q. What has been the effect upon this 40 or 45 miles of river in regard

to deepening it? Did it really confine the channel to a thousand feet, or to practically that?—A. Very successfully; yes, sir.

Q. It made the river deeper than it was before?—A. Yes, sir; it gave a depth of 10 or 12 feet at low water.

Q. Through that whole 45 miles?—A. Yes, sir.

Q. Did the narrowing of the channel tend to scour out the bottom?—A. Yes; it did.

Q. It had that effect?—A. Yes, sir.

Q. And deepened the channel, by the scouring process, where it was narrowed?—A. Yes, sir.

Q. And confined?—A. Yes, sir. It also tends to lower the surface.

Mr. NELSON. The surface of the water?

The WITNESS. Yes.

Q. Instead of raising the bottom it lowers it, you think?—A. It lowers the surface, I know, and of course it scours the bottom.

Q. It scours the bottom and deepens the channel rather than to raise the dirt higher?—A. Yes, sir.

Q. You think the effect of the narrowing and confining of the channel by the work that has been done has a tendency to deepen the channel and to scour and not raise the bed of the river?—A. Yes, sir.

Q. You are satisfied that that is the effect of it?—A. Yes, sir.

Examined by Mr. GALLINGER:

Q. Captain, is the river easily navigable from Kansas City to St. Louis at all seasons of the year?—A. Well, under present conditions it is not any better river there than it is here. It is wider in proportion to its increased volume of water, but the depths on the crossings are no better than they are in this part of the river. About 30 inches at low water down there and about the same up here is what you can count on. The channels are a little wider, not so narrow and tortuous down there, but the depth is about the same.

Q. Then, as a matter of fact, there is comparatively little commerce on the river between those two points?—A. Very little.

Examined by Mr. NELSON:

Q. There is really, then, no steamboat navigation below Kansas City of any consequence?—A. There is no navigation as far up as Kansas City. There is a boat that runs about one-half of the distance up from St. Louis to Kansas City, or was when I was at St. Louis.

Q. One boat only?—A. One boat only.

Q. Is that the whole commerce?—A. That is all the through long-distance commerce. There is quite a little short-distance commerce, where they go around and pick up what farmers have to ship and take it to a railroad station or to flour mills, 10 or 15 miles—something of that sort.

Q. But no regular steamboat navigation, with the exception of one boat?—A. No through navigation except that.

Examined by Mr. BERRY:

Q. Captain, are you of the opinion that if the work as contemplated and as done from Jefferson City down 40 miles could be done all the way from Kansas City to St. Louis, it would so increase the depth of the water that it would afford a deeper channel and carry larger boats all the way through?—A. Yes, sir.

Q. You have no doubt that if money enough should be expended to do that thing it would so improve the river as to give increased facilities for commerce?—A. I haven't the slightest doubt of it.

Examined by Mr. NELSON:

Q. Are there any important tributaries flowing into the Missouri River between Kansas City and the mouth?—A. Yes, sir; right at Kansas City is the Kaw River, and there is the Little Blue and the Big Blue.

Q. They come from the Ozark range, don't they, those two?—A. They are farther north than the Ozarks.

Q. And then there are the Osage and the Gasconade rivers below?—A. Yes.

Q. The Osage is subject to some floods at high water?—A. Very heavy floods.

Q. Are there any places from here down that would be suitable for good reservoirs, large enough to aid navigation, or in diminishing the floods of the Lower Mississippi? Can you think of any place from here down that would afford big holding grounds, and where dams could be built at moderate expense, that would create reservoirs that would be of material benefit to navigation during low water, or that would tend to reduce the floods of the Lower Mississippi?—A. I don't think in the river proper it would be practicable at any reasonable cost. At the head waters of any of these tributaries, though, it very likely would be.

Q. And possibly at some of these tributaries those reservoirs might be utilized for irrigation, too?—A. Yes, utilized in irrigation.

Q. I would like to ask you as an engineer what, in your opinion, can be done, if anything, on the Missouri or its tributaries that would tend to materially diminish the floods on the Lower Mississippi? Can you think of anything of a practical character that would be of any material assistance in diminishing the floods at high water in the Lower Mississippi? In other words, can we do anything up here in a reasonable manner and within reasonable limits of expense to hold back the Missouri River, at high water, so as to let less water down on them at flood tide in the Lower Mississippi; and if so, what do you think could be done—what would you suggest?—A. I should say, sir, that simply as a means of restraining floods, the cost would be enormous in comparison with the benefits you could get. If you combine irrigation with that, I have no doubt the benefits derived above from the irrigating of the land would in many cases pay for the Government's doing the work, if it were to reap the benefit.

Q. That is, if the Government were to reap the benefit of it?—A. Yes, sir.

Q. From the increased value of the land?—A. Yes, sir. The best place I know of to build a reservoir is above Great Falls. Many of the tributaries of the Yellowstone are large streams, come out of the mountains, and investigation might show that some of those streams would be susceptible to such an improvement.

Q. Has the Government done anything in the way of levees on the Missouri River at any point?—A. No, sir; it is not considered that they would pay for themselves on the Missouri, the floods are so few and far between.

Q. Is there anything else on this subject that you can think of that we ought to know, and that would be valuable information for Congress?—A. You have just examined into the reservoir system of the Upper Mississippi. I have never been there. There is no question but that a certain number of reservoirs (I don't know how many), of probably similar capacity in the aggregate to those at the headwaters of the Mississippi, built at the headwaters of the tributaries of the Yellowstone,

possibly in the Yellowstone itself, surely in the Upper Missouri and its——

Q. The Cheyenne?—A. Yes, sir. It is only a question of the value of the results as compared with the cost of the work. You know what results have been attained by the reservoirs on the Mississippi; they don't seem to be excessively great.

Q. And that question you couldn't determine without a careful survey?—A. No, sir.

Examined by Mr. GALLINGER:

Q. One branch of the resolution under which we are acting, Captain, charges us with the duty of inquiring into the question of the feasibility of decreasing the damage caused by floods in the Lower Mississippi, by diverting the water through an artificial channel. Have you given any thought to that subject?—A. The outlet system?

Q. Yes.—A. Yes, sir; I have, some. I made something of a study at one time of the crevasses of the Lower Mississippi—the effect of them. The general effect, I think, is very injurious to the regimen of the river.

Q. Is it your opinion, Captain, that silt would be carried through that opening, and that it would soon be clogged up?—A. I think it is highly probable it would. I think the river below it would be pretty nearly ruined.

Q. In other words, you think there would be danger of diverting the main channel of the river, do you?—A. Well, I think the river below it would be left in a very much worse state. Of course, with two outlets to the river both of them are apt to be bad; the bottom left in a high state; not cut out.

Q. Where there is a crevasse made, isn't the result to create a sandbar in the main river below where the crevasse occurs? For instance, there is a break in the levee, a crevasse takes place. I want to ask you if the result of that isn't that a bed forms immediately below that break, in the main river?—A. I should say so. A very slight obstruction causes a deposit.

JOHN H. CHARLES, having been duly sworn, testified as follows:

Examined by Mr. BERRY:

Q. I would like to ask you whether there is less water in the river now than there was in the old steamboat days; whether the river is more shallow, and whether there is more difficulty in navigating the river on account of there being less water than in former days?—A. I don't think there is any more difficulty in running steamboats on this river now than there was forty years ago. There is probably a little less water, but there is always a certain amount of water in this river, as the Captain has told you, and there are shallow places, but 2½ feet is probably as shallow as it gets. There is always water enough to make it that much. After there is a flood in the river the navigation is worse than before the flood, because the flood has a tendency to level up the river—fill up the bottom of the river—and then when the flood subsides it wears the channel out—cuts out a channel—and it don't take much of a channel to float a steamboat in a river as large as this. Almost always where you find a current there is a channel wide enough to get through.

Q. You have been acquainted with the Missouri River, watching its progress and the steamboat business, for a good many years, haven't you?—A. Yes, sir. I came onto the Missouri River in 1850. The navi-

gation of this river has run down because the men who were connected with the steamboats did not have the right kind of spirit. I have been in hopes someone would come along and build some steamboats that could do some business on this river. There is enough business now to pay to run two boats between most every town on the river—for instance, between here and Yankton, between Yankton and, say, Castralia or Wheeler, Yankton and Chamberlain. There is always business enough that a steamboat can get from the opposite side of the river from a railroad and bring down to the next railroad station for just what it will cost to cross on the river. It costs 10 cents a hundred almost anywhere to cross the river on a ferry, and that 10 cents will pay a steamboat that is in the business to bring it down to the next railroad crossing and deliver it to the railroad there and take whatever they may have for towns on the other side and deliver it and bring their produce to the next station, and so on.

Q. But steamboat men haven't looked at it in that light.—A. Fifteen years ago they had a first-rate thing, and they thought it was so good that nobody could get it away from them; they thought the railroads were rather weak institutions and had to dig for their lives; but they have succeeded in getting every man that had a good idea—an idea that would enable him to do business for less money—they would either get the business by buying him up or cheating him out of it, or getting it somehow or other, and the result is they have brought down the business of the railroads to almost perfection. And they are following the same course yet. When I came up the river on the *El Paso* (was going up for the fur company), she had the same kind of a wet-behind wheel that we have to-day, the same kind of big valves, the same kind of a furnace. We stopped at every bend we came to and took on all the wood we could pile on, and sometimes hired a flatboat and filled that and took it along. That sort of business might pay when money was plenty, but when it got down to brass nails, as we say, that wouldn't go, they were left. If I was a young man I think I could put a scheme into execution that would carry the business and make money at it; but I am too old.

Q. I wish you would state whether or not you think the reduction of steamboat navigation is attributable to competition of the railroads or to less water in the river?—A. There is no doubt, I think, but what there is less water in the river to-day than there used to be, but I don't think the difference is such as to work against the running of the boats. I think there is an abundance of water. Don't you, Captain?

Captain SANBORN. I think there is just as good depth, probably.

The WITNESS. And after there has been a flood, the navigation is always poorer than before the flood, because of this cutting out of the channel. There is no doubt that in former times when it rained hard there were more sudden rises, perhaps, in the river than there are to-day. The amount of rain, as I understand it, is about equal to what we had half a century ago, or a quarter of a century, anyway; the difference is but very little; the average perhaps would be the same. But the reason the river doesn't rise immediately after a heavy rain is because our prairies are cultivated, and the soil is such in the Missouri Valley that when the rains fall they sink right down into the ground and it takes a long time for it to come out again by way of the streams, and I think that really helps to keep up the river—acts as a sort of a gauge.

ST. LOUIS, MO., *October 28, 1897.*

Lieut. Col. AMOS STICKNEY, having been duly sworn, testified as follows:

Examined by Mr. NELSON:

Q. Colonel, are you president of the Missouri River Commission?—A. I am, sir.

Q. How long have you occupied that position?—A. Since the 11th of February, 1896, I believe. Before that I was acting president, from January 14, the time I was appointed a member of the commission to succeed Colonel Suter, who was the former president.

Q. What part of the Missouri River does the Missouri River Commission have in charge?—A. From Sioux City to the mouth of the Missouri River.

Q. About what is the distance?—A. About 800 miles.

Q. Approximately what is the distance from Sioux City to Kansas City?—A. Kansas City is nearly halfway between Sioux City and the mouth of the river, about 390 miles above the mouth.

Q. What navigation, if any, is there on the Missouri River above Kansas City?—A. There is very little, scarcely any at all; only some boats for local trading.

Q. But there is no regular steamer plying up and down?—A. No, sir.

Q. There hasn't been for years, has there?—A. Not for some time; I couldn't say just how long. I could only say by reference to the records.

Q. Well, there is none now and hasn't been since you have been president?—A. No, sir.

Q. No business up and down the river on that reach. From Kansas City to Sioux City, have any improvements been made on the river, aside from so-called harbor improvements? By harbor improvements I mean such as are made in front of towns or near railroad bridges, etc.—A. There have been detached works, usually for the protection of banks, to stop the erosion of banks.

Q. That has been only in isolated places?—A. Yes, sir.

Q. Not so much to improve navigation as to prevent the land from falling into the river?—A. It prevents the land from falling into the river, and it usually fixes the channel of the river, but not always.

Q. Now, you understand what I mean by harbor improvements, so-called?—A. Yes, sir.

Q. Aside from so-called harbor improvements, at what places have these improvements been made, and of what nature?—A. I shall have to refer to the records; I have sent for them.

Q. In these matters I do not expect you to be absolutely correct.—A I shall have to give that to you later, Senator.

Q. All right; you may supply that. Now, at what points between Sioux City and Kansas City are there harbor improvements? There are some at Omaha, aren't there?—A. Yes; since I have been on the commission there has been work just above Omaha, on the Council Bluffs side; and next below that, at Nebraska City, and at Leavenworth. There have been improvements made at a number of other points; I will give you those when I get the record.

Q. But Nebraska City and Council Bluffs are the main points?—A. And at Leavenworth, during this year. Other points for previous work will be given from the records.

Q. What is the nature of those improvements, and the purpose of

them?—A. The improvement at Council Bluffs was to prevent the cutting away of the bank and to regulate the flow of the river past a certain bend where the river had cut into the bank and made a bad bend in the river.

Q. Was it indirectly to protect a railroad bridge there?—A. No; I can't say that it was. It was to protect Council Bluffs.

Q. The town?—A. Yes.

Q. From being undermined?—A. At the upper part of Council Bluffs the river had cut in and made a very bad bend.

Q. What is the character of this work—revetment work, as it is called?—A. Some of it is revetment work, and there is considerable dike work.

Q. Revetment work is of willow mattresses with stone on top, or something of that kind?—A. Willow mattress under water and a stone covering above low water.

Q. And the dike work is something like wing dams?—A. They are permeable dikes, built of piles. At this particular place the dikes were thrown out from the shore to fair up the channel at that point and throw it out of this bend.

Q. The object of those dikes is to accomplish about the same purpose as wing dams do in other places, is it not?—A. That is what they are for, usually. They are usually for regulating the width and the direction of the channel, and sometimes to protect the bank.

Q. Is the work at Leavenworth and Nebraska City of the same character?—A. Yes, sir; this year's work is.

Q. What was the object of the work at Nebraska City?—A. The object of the work that was put in (some years ago) was to protect a bad bend on the opposite side of the river from Nebraska City; then additional work to protect a bend made by a cut-off which was threatening the railroad bridge and the approaches. The work that is now contemplated there is to throw the river out of the bend, for two purposes: In the first place, to fair up the channel at that point, and, secondly, to prevent its falling away across a middle bar and cutting the bank on the Nebraska City side. That work is projected, but not completed.

Q. The other work (at Council Bluffs) is completed?—A. That is completed.

Q. What is the object of the work at Leavenworth?—A. The work that has been put in there this year is to protect the cutting away of the point on the Government reservation opposite Fort Leavenworth, which was having a bad effect in two or three ways. In the first place it was throwing the channel away from the Fort Leavenworth side, also threatening the railroad bridge, and threatening to disturb the regimen of the river below in front of the city of Leavenworth. Previous work will be given from the records.

Q. And the work there is of the same character as at these other places?—A. It is dike work this year. In previous years both dike work and revetment.

Q. Is that completed?—A. The work projected this year is just about completed now—that is, it is completed as far as we could go with it at present. It may need some extension.

Q. Could you give, in round numbers, about the cost of these different improvements where they are completed, or the contemplated cost where they are not completed?—A. Yes, sir. I have records of all those places on the river. I would have to refer to the records.

Q. Will you please supply that, as to Council Bluffs, Leavenworth,

Nebraska City, and Atchison, so it can be incorporated in the testimony?—A. Yes, sir.

Q. I wish you would prepare for us a statement giving all the points between Kansas City and Sioux City where improvements have been made by the Missouri River Commission, the cost of those improvements, and their nature. State, for instance, whether it is dike work or revetment work, or both, and whether it is what is called harbor improvement or simply work to improve the channel of the river.

In answer to the last question witness submitted the following statement, marked Exhibit G:

EXHIBIT G.

List of localities on the Missouri River between Sioux City, Iowa, and Kansas City, Mo., where improvements have been made by the United States, with character of improvement, and appropriations.

OMAHA, NEBR., AND COUNCIL BLUFFS, IOWA.

(660 miles above mouth.)

Object of work.—In 1878 a cut-off of a bend 16 miles in length, immediately above Omaha, occurred, resulting in a greatly increased local slope and velocity and consequent increased rate of caving of both banks. This caving, if allowed to continue, would eventually result in throwing the steamboat channel obliquely across the Union Pacific Railroad bridge.

All the work done by the United States has been directed to maintaining the bank lines and the steamboat channel in a position at right angles to this bridge and also to that of a later one completed in 1888.

By revetment of the banks much valuable property on both sides of the river has been incidentally protected, the safety of the bridges assured, and a deep-water front preserved for the city of Omaha. On the Council Bluffs side, especially, the recent extensive revetment and dike work have protected the erosion of the banks.

Reference to Chief of Engineers' reports.	Appropriations and allotments.	Character of work.
1878	$80,000	
1879	50,000	Banks revetted 4,600 linear feet on Nebraska side.
1880	20,000	Banks revetted 15,000 linear feet on Iowa side.
1881	30,000	Temporary floating brush dikes built, and revetment work kept in repair.
1882	20,000	
1883	.....	
1884	.....	
1888	150,000	
1890	85,000	Iowa bank revetted in bend above Omaha, 26,800 linear feet.
1892	30,000	
1893	16,800	
1894	75,000	
1895	.....	A system of spur and training pile dikes built to screen a pocket in Iowa bank caused by failure of revetment.
1896	40,000	
1897	.....	

PLATTSMOUTH, NEBR.

(635 miles above mouth.)

Object of work.—To train the river in front of Plattsmouth, and improve the approach to the railroad bridge.

Reference to Chief of Engineers' reports.	Appropriations.	Character of work.
1880	$10,000	Temporary wire screen and brush dikes built.
1881	10,000	

NEBRASKA CITY, NEBR., AND EASTPORT, IOWA.

(608 miles above mouth.)

Object of work.—The preservation of the water front of Nebraska City by the maintenance of the bank line on the Iowa side and the rectification of the channel line above.

A considerable amount of railroad property was protected by the revetment.

In 1886–87 the river abandoned the bend on the Iowa side and ran through the chute in front of the town; subsequent work was placed to hold the bank of the island opposite Nebraska City, which if allowed to continue to cave would endanger the safety of the bridge, produce an oblique channel through it and result in caving on the Nebraska City front.

Reference to Chief of Engineers' reports.	Appropriations and allotments.	Character of work.
1876	$15,000	
1878	40,000	Temporary floating dikes and other expedients built for rectification of channels.
1879	30,000	
1880	14,000	
1881	20,000	17,500 linear feet revetment placed on Iowa bank in Eastport bend.
1882	35,832	
1883		
1888	75,000	5,750 linear feet revetment placed on island opposite Nebraska City.
1890	10,500	
1891		
1896	5,000	Construction of 3 dikes to check enlargement of a pocket formed at head of revetment of Nebraska City Island.
1897	25,000	Construction of 3 dikes to regulate the channel.

BROWNVILLE, NEBR.

(578 miles above mouth.)

Object of work.—The original project contemplated a considerable bank revetment, but appropriations being too small, efforts were made to rectify the channel by closing chute behind island.

Reference to Chief of Engineers' reports.	Appropriations.	Character of work.
1880	$10,000	
1881	10,000	Temporary wire screens and brush dikes built across Sonora Island Chute.
1882		

RULO, NEBR.

(537 miles above mouth.)

Object of work.—The protection from further caving of the Missouri bank 3 miles above the railroad bridge.

Reference to Chief of Engineers' reports.	Appropriations.	Character of work.
1888	$50,000	
1890		4,922 linear feet of revetment placed on left bank.
1891		

ST. JOSEPH, MO.

(480 miles above mouth.)

Object of work.—Primarily the protection of the banks from caving and the possible formation of a cut-off which would leave St. Joseph an inland town and its bridge spanning a slough.

A cut-off occurred at Amazonia, above St. Joseph, in 1880, and increased the rate of bank caving.

All the work has been that of bank protection by revetment and rectification of channel by dike work, with a view of subserving first the interests of navigation and at the same time the protection of local property.

The work done at St. Joseph would entirely fit in with a scheme of general improvement of the river.

Reference to Chief of Engineers' reports.	Appropriations and allotments.	Character of work.
1876	$10,000	Banks revetted in Elwood Bend near bridge company's spur dikes.
1877	.....	
1878	50,000	
1879	9,000	The following amounts of revetment were placed on banks in bends above St. Joseph and kept in repair:
		Linear feet.
		Elwood Bend 14,740
		Belmont Bend 14,246
		Bonton Bend 19,332
		St. Joseph front 2,000
		Total 50,318
		A considerable amount of dike work was also built, having for its object the training of the channel, as well as for protection of the banks, but nearly all of it has been destroyed by floods and ice.
1880	20,000	
1881	20,000	
1882	(a)	
1883	.....	
1884	105,000	
1885	.....	
1886	.....	
1887	.....	
1888	65,000	
1889	.....	
1890	101,000	
1891	.....	
1892	.....	
1893	30,000	
1894	22,000	
1895	.....	
1896	.....	

a An allotment of $324,000 from the appropriation of 1882 was expended between Charleston, Kans. (27 miles above St. Joseph), and Lexington, Mo.

ATCHISON, KANS.

(448 miles above mouth.)

Object of work.—The protection of the Missouri bank above the railroad bridge against erosion and the straightening of the channel approach to the bridge. The left bank continued to cave until it formed a deep bend, imperiling the safety of the bridge and rendering it wholly impassable to steamboats.

A cut-off occurring in 1891 in the bend above caused an increased velocity of flow and rate of bank cutting.

In 1895 the river abandoned the old bend and took its course through the chute of Atchison Island, forming a new channel very favorable in its approach to the bridge. Great changes have occurred since this last cut-off, and the object of contemplated work will be to train the channel by dikes or other works not yet planned into a suitable and permanent approach to the draw opening of the bridge and prevent the river from wandering back and forth for some miles above.

Reference to Chief of Engineers' reports.	Appropriations and allotments.	Character of work.
1878	$20,000	
1879	20,000	Missouri bank revetted for a length of 8,822 linear feet.
1880	20,000	
1881	20,000	Temporary wire-screen dikes built for diverting channel.
1882	(a)	
1883	.....	
1888	75,000	
1889	.....	Missouri bank revetted for a length of 1,954 feet. Permeable pile dikes, aggregating 3,564 linear feet, placed on Missouri side to induce accretion and to direct channel at right angles to bridge line.
1894	35,000	
1895	.....	Missouri bank revetted for a length of 6,300 linear feet, the dikes of 1888 and 1889 having been washed out.
1896	15,000	

a An allotment of $324,000 from the appropriation of 1882 was expended between Charleston, Kans. (27 miles above St. Joseph) and Lexington, Mo.

FORT LEAVENWORTH AND LEAVENWORTH, KANS.

(424 to 422 miles above the mouth.)

Object of work.—The earlier work contemplated the restoring of the river to as stable a regimen as the available means allowed by the revetment of the Missouri shore in the bend above the fort, where excessive caving was going on, and the rectification of the channel by the use of floating dikes to induce fill.

The work was very successful while it lasted, but in the absence of repairs much of it was destroyed by floods and ice and was replaced by new revetment work in 1889–90.

The work of 1895–96 was the building of two permeable pile dikes on the Missouri side between the two bridges, closing one of the two existing channels and throwing it to the Leavenworth side, thus giving it a better direction to the draw opening of the lower bridge and incidentally protecting the left-bank approach and shore pier of that bridge.

The work of 1897, consisting of three permeable pile dikes jutting from the Missouri shore above the fort, has for its object the throwing of the current toward the Kansas side and the eroding of the bar which had formed in front of the fort landing and the preservation of the point on the Missouri side which, if allowed to cave farther, would make steamboat passage through the bridge difficult and endanger the safety of the structure, besides having a deleterious effect on the river between the two bridges and in front of Leavenworth.

Reference to Chief of Engineers' reports.	Appropriations.	Character of work.
1878	$25,000	
1879	10,000	Nearly 13,000 linear feet of revetment placed on Missouri shore of Bee Creek Bend. Much of this was destroyed by the floods of 1881 and 1883.
1880	8,000	
1881	8,000	
1882		
1888	75,000	
1890		Heavy revetment of Bee Creek Bend; 6,658 linear feet placed.
1894	28,000	
1895		Two permeable pile dikes on Missouri side, between the bridges, aggregating 2,040 feet in length.
1896	15,000	
1897		Three permeable pile dikes on Missouri side above the Fort bridge.

KANSAS CITY, MO.

(390 miles above mouth.)

Object of work.—Previous to 1882, when the first appropriation for a systematic improvement of the river was made by Congress, the work carried on under three small appropriations consisted of revetment of banks in bends above the city and the use of temporary floating dikes with a view of stopping the extensive erosion, which was not only endangering large commercial interests and the safety of the railroad bridge, but was rendering navigation difficult and hazardous, especially in the vicinity of the bridge. At that date the engineer officer in charge, in carrying out the scheme for a systematic improvement, decided on Kansas City as the proper starting point for such work, and this view was adopted by the Missouri River Commission, created by the act of July 5, 1884.

As far as the succeeding appropriation acts would allow this plan was carried out up to 1890, when the act of that year directed that the work of systematic improvement should proceed from the mouth up in reaches to be determined by the commission and approved by the Secretary of War.

The work at Kansas City was then suspended, except some repair and slight extension of existing works.

The improvement was carried below Kansas City only about 4 miles, while the work above extended into Little Platte Bend, about 13 miles.

The work consisted both of revetment and of permeable pile dikes having in view the rectification of channel and the holding of banks with the consequent protection of local interests as incidental. The work was successful but has deteriorated in the absence of repairs.

Reference to Chief of Engineers' reports.	Appropriations and allotments.	Character of work.	
1879	$30,000	Light revetments of banks in Kaw and Quindaro bends.	
1880	25,000	Temporary brush dikes built in Kaw Bend to induce fill.	
1881	20,000	Revetments in Kaw bend extended.	
1882	(a)	Revetment of banks above Kansas City:	Linear feet.
1883		Kaw Bend	10,694
1885		Quindaro Bend	9,760
1886		Little Platte Bend	7,770
1887		Revetment of banks below Kansas City:	
1888	110,000	East Bottoms	7,035
1889		Harlem	5,436
1890		Dike work:	
1891		Little Platte Bend	2,056
1892		East Bottoms	1,058
1893		Harlem	6,120

a An allotment of $324,000 from the appropriation of 1882 was expended between Charleston, Kans. (27 miles above St. Joseph), to Lexington, Mo.

Q. My understanding is, Colonel, that there has been no systematic effort to improve the river, as a river, between Kansas City and Sioux City?—A. Efforts have been spasmodic; yes; that is, work was at places separated from each other—not continuous.

Q. That the improvements have been simply to protect certain places against inroads of the river, and not for the purposes of navigation?—A. Yes, sir; largely for that, though they had some effect on navigation, and in some places would fit into a general scheme of improvement.

Q. That is why I make a distinction between these two reaches of the river: And you have already stated that there is really no steamboat commerce, to speak of, between Kansas City and Sioux City?—A. I will refer to our records and give you a statement as to just what kind of commerce there is and what it amounts to. I would rather do that than to answer the question offhand, because on that part of the river they sometimes put on a small boat at some place for a little while and take it off again. During the last two seasons (since I have been a member of the commission) the commission has done no work above Omaha.

In further answer to the last question, witness submitted the following statement, marked Exhibit H.

EXHIBIT H.

Number and approximate tonnage of steam and gasoline vessels engaged in trade on Missouri River between Kansas City, Mo., and Sioux City, Iowa, for various years, including those engaged in ferriage.

Year.	Number.	Tonnage.
1891	11	713
1892	9	819
1893	10	515
1894	8	281
1895	6	200
1896	6	274

The smaller vessels usually tow barges, which are not included in the above table.

Amount of business, not including ferriage, carried on the Missouri River between Kansas City, Mo., and Sioux City, Iowa, for the years 1891 to 1896, inclusive.

Year.	Total products carried.	Average distance carried.	Number of vessels, steam or gasoline.
	Tons.	*Miles.*	
1891	31,249	2.8	2
1892	30,189	3.9	3
1893	80,746	2.1	3
1894	17,277	4.1	2
1895	15,144	3.2	3
1896	12,771	3.5	4

The traffic with barges is included in the totals, and also that of timber rafts. A small portion of trade above Sioux City is included in the totals of 1892.

Q. During that time it has done really no river work, except between Omaha and Kansas City—no real work except to stop up these little holes?—A. We have done no systematic work of improvement up there, but the work done during the last two seasons is all helpful for channel improvement.

Q. No work that you could say was for the purpose of making it a navigable river, but rather to prevent the river from doing harm in certain places?—A. Yes; but I think we ought to bear in mind the fact that those places generally where the bank is protected are where the channel of the river is—are where the strong current strikes the bank, and in protecting the bank and holding it you often fix the channel of the river along there, and in that way that work might be considered to aid in the improvement of navigation.

Q. Yes; indirectly.—A. Indirectly, yes.

Q. What is the distance, in round numbers, from Kansas City to Sioux City?—A. It is about 400 miles.

Q. And from Kansas City to St. Louis?—A. About 400—it is 390 and a fraction.

Q. Is there any steamboat navigation of any consequence on the Missouri River between Kansas City and the mouth?—A. Only some small boats running between local points.

Q. No through navigation?—A. Just at this time there is no through navigation.

Q. And hasn't been for some years, has there?—A. Yes, sir; for a part of the way. There have been steamers running from St. Louis up to about the vicinity of Arrow Rock.

Q. How far up is that?—A. That is above Jefferson City—about 221 miles up from the mouth.

Q. You say there has been some navigation up there. One boat or more?—A. Well, one boat at a time, you might say, that was running regularly.

Q. How many trips has it made in the course of the season?—A. When they were running I think they made weekly trips.

Q. How long since they quit running?—A. The boat that was in that trade was destroyed by the cyclone here over a year ago.

Q. And there has been none since?—A. There has been no boat since; that is, no boat that goes any distance up the river.

Q. Isn't it a fact, Colonel, that there is really no through steamboat navigation on the Missouri?—A. Practically none.

Q. There is nothing but a few very small steamers plying between local points?—A. That is all. I noticed in the paper yesterday (I don't

know whether there is any truth in it or not) that a line was to be established next year to Kansas City.

Q. What is the stage of the water in the Missouri River from Kansas City down?—A. Exceedingly low—almost down to the lowest stage that ever was known.

Q. How much water in the channels?—A. Well, as a general thing there can be found channels in the Missouri River with nearly three feet of water.

Q. Hardly that now, is there?—A. Well, almost everywhere there is. There are some shoaler places.

Q. Your snag boat went up to Kansas City recently. How much does your snag boat draw?—A. Three feet.

Q. Did she have any difficulty in going up?—A. Yes; she had difficulty in going up at several places.

Q. Please state the general nature of the improvements you have been making on the river between Kansas City and the mouth.—A. The principal improvements have been in the line of what is called the systematic improvement of the river—of the first reach. There has also been some work at detached points.

Q. You have divided it into three reaches, haven't you?—A. Yes, sir; three reaches to Kansas City, and three from Kansas City to Sioux City.

Q. The first reach extends from the mouth how far up?—A. Originally it was to the Osage River, but it was carried a little farther than that, just above Jefferson City, to reach a suitable place for beginning. There, in the upper part of the reach, is where the work has been done in that reach.

Q. Has any work been done on the middle reach?—A. No, sir; that is, no systematic work.

Q. Where does the second reach extend from?—A. From the end of the first reach, I think, to Grand River, although I am not certain of it; I am not sure as to the exact limit of that reach.

Q. No work has been done on that?—A. No systematic improvement work has been done on that.

Q. On the reach up to Kansas City there was some work done some years ago, wasn't there?—A. In the vicinity of Kansas City; yes, sir; and just above and below Kansas City.

Q. Nothing has been done of recent years on that reach at all?—A. No, sir. In 1891 work was commenced on the systematic improvement, beginning just above Jefferson City, and was carried on energetically for the four or five years when there were large appropriations, down to the Gasconade River, a distance of about 45 or 46 miles.

Q. Below Jefferson City?—A. Yes, sir.

Q. On the west side of the river, between Kansas City and St. Louis, there are two principal streams, are there not, the Gasconade and the Osage?—A. Yes, sir.

Q. Does the Meramec River empty into the Missouri?—A. No, sir; those are the principal rivers, and then there is the Lamine above them.

Q. Now, you say on the second reach there have been no improvements at all?—A. There has been no systematic work; work has been done at detached places.

Q. And since when were the improvements suspended on the upper reach?—A. I think it was in 1892.

Q. And since 1892, or about that time, there have really been no improvements on the upper reach?—A. Except at detached points; there has been no systematic work.

Q. There have been so-called harbor improvements?—A. Yes.

Q. And the improvements since 1890 on the lower reach have been below Jefferson City?—A. Below Jefferson City. Well, starting from a point a short distance above Jefferson City (4 or 5 miles), and working downstream.

Q. Down to the mouth of the Gasconade?—A. To the mouth of the Gasconade, and this year a little detached work.

Q. What has been the nature of that work?—A. That work has been an almost complete rectification and control of the river to form channels for navigation and prevent destruction of land.

Q. Making a narrower channel?—A. Yes, sir.

Q. Does it consist of what you call dikes, or what we call wing dams up the Mississippi?—A. Yes; permeable pile dikes to contract the channel, and revetments on the banks to protect the banks, and some bank heads.

Q. Have those revetments been in the nature of riprapping, or have they been simply willow mattresses with rock on top?—A. Mattresses weighted down with rock under water, and rock above low water on the bank.

Q. What has been the result of that work, so far as you know?—A. The result of it, where it has been completed, has been to make a very decided improvement.

Q. To narrow and deepen the channel?—A. Yes, sir.

Q. Would the effect of it be to scour and make the channel deeper?—A. Where the width is contracted that is the effect.

Q. Taking the year through—not merely the flood period—has there been a gradual diminution in the supply of water in the Missouri River, of recent years, or has there been as much of recent years as there was before?—A. That is a question I have never investigated. I don't suppose there has been any very great diminution.

Q. Are there any points on the Missouri River between here and Sioux City, or on any of its chief tributaries on that reach of the river, that would afford large holding grounds suitable for good-sized reservoirs?—A. I am unable to answer that question, because it is a matter I have not yet investigated. The subject has never come up with this commission since I have been a member, but Captain Chittenden has been making some examinations under my direction. His report has not yet been submitted.

Q. Are there any places within the bottoms of the Missouri River where reservoirs could be made?—A. None that I know of that would be of any considerable consequence in controlling the river.

Q. Are there any places on the Kaw (or Kansas) River, or on the Platte, or the Gasconade, or the Osage?—A. Well, the first two of those rivers are not in our jurisdiction; the Gasconade and Osage are, but the other rivers are not.

Q. Are there any places you know of on the Gasconade or the Osage that would afford good ground for suitable reservoirs?—A. No, sir; I think not; nothing of any extent, though I have not investigated that.

Q. What is the character of the floods on the Missouri River here? Were they unusually high last spring as compared with former years?—A. They were not unusually high, but the early flood was rather extended in time on this lower river.

Q. Of long duration?—A. Yes; but there was no excessive increase in the volume of water at any one time.

Q. It didn't exceed in height other periods of high water?—A. No, sir.

Q. In fact, not as high?—A. No, sir.

Q. The chief distinguishing feature of it was the long duration of the

flood, was it not?—A. Yes; the spring flood was rather longer than usual.

Q. At what time do you have the spring flood here—what time does it reach the lower Missouri?—A. It varies; but about the latter part of March—the latter part of March to some time in April.

Q. Have you any idea from what tributaries of the Missouri River the chief floods are derived?—A. I think the largest part of the spring flood comes down the main river—a general contribution from all the tributaries—but occasionally in this lower river we get a very excessive flood, which is of very short duration, out of the Osage.

Q. The Osage starts away back in Kansas or in the Indian Territory, doesn't it?—A. Yes; and comes in a few miles below Jefferson City.

Q. That is subject to floods occasionally?—A. Yes, sir. Sometimes we have a very sharp flood with a great deal of water coming out of that river, but it is of very short duration.

Q. How is the Gasconade?—A. We don't usually get so much out of that.

Q. That starts in the Ozark Mountains somewhere?—A. Yes.

Q. How about the Platte?—A. Well, the Platte I am not so familiar with. I don't know about that, as our work has been lower down since I have been connected with the river.

Q. In your opinion what, if anything, can be done with the waters of the Missouri River that would tend to diminish or lessen the floods in the lower river at high water? Suppose they are suffering from floods in the lower river. The Missouri River contributes a certain amount of water. Now, what can be done by way of checking or restraining the Missouri River from contributing its share to the disaster?—A. Well, the question of floods in the lower river, by which I understand you to mean the Lower Mississippi (where the greatest devastation occurs), is quite a complex one. You must take into consideration all of the large streams that contribute to the flood. I have had some investigation made on that point and have had some diagrams made which I would like to show to you.

Mr. NELSON. Well, before we proceed with that are there any questions you would like to ask in regard to the Missouri River, gentlemen?

Examined by Mr. BERRY:

Q. Colonel, with a reasonable amount of money do you think it would be possible to so improve the Missouri River as to make it practicable for boats drawing about 3 feet of water to run, during low water and at all times, from here to Kansas City?—A. I think there is no doubt whatever about the possibility of getting navigable channels with sufficient depth to accommodate good-sized boats drawing 3 feet or more. We can get channels from 5 to 6 feet deep at the lowest stages. That has been demonstrated beyond any question by the work of the commission in the first reach—from Jefferson City down—and the only point is the great amount of money it has cost and the length of time it has taken to do the work. The commission is now investigating the subject of reducing the cost very materially and getting equally good results. I think the work of the commission during this year will develop something in that regard. The cost of the work on that part of the river where the improvement is nearly completed has averaged between $40,000 and $45,000 per mile. My hope is to reduce the cost to something less than 30 per cent of that. If we can do that (and I think this year will go far toward demonstrating what we can do) by adopting a different system of work, I think there will be no question about the possibility and the desirability of making a perfectly safe navigable channel

to Kansas City, and at the same time prevent the destruction of hundreds of thousands of acres of fertile lands.

Q. To what do you attribute the decline of steamboat navigation on the Missouri River from what it formerly was? Is it attributable to the fact that steamboats can't compete with the railroads, or to the difficulty of navigating the river?—A. It is a combination of both. The Missouri River has plenty of water in it at all times to make navigable channels, and, as a usual thing, there is a channel at all points with about three feet of water in low water. But that channel is variable; it changes about from one part of the bed to another, and very rapidly. Sometimes overnight a channel will change from one side of a bar to the other side. The consequence of that is that the navigation is hazardous, and boats are unable to run at night, and I think the insurance on the boats is so heavy that it is found not profitable to run the boats, especially when there are railroads running along the river that can carry all the freight that is offered. But if the river were safe for navigation, so lines could be put in and run with regularity, I think there is no question but that there would be considerable commerce developed on the river.

Q. Does the narrowing of the channel of the Missouri River tend to deepen the channel, to scour it out and to lower the bed, or is the effect of narrowing the channel to raise the bed of the river?—A. Without any question whatever it cuts the bed down, sometimes as much as 10 or 15 feet. But there is one feature about the lowering and raising of the bed of the river that I think is not generally understood by laymen. In times of flood, when the velocity of the water is very great, the bottom of a river like the Missouri or the Lower Mississippi, is cut out very much; quite a deepening takes place. As I say, in the Missouri River we have deepenings of as much as 10 or 15 feet, or more. And, as the flood subsides, the moment the velocity begins to get less, the material that is carried in the river begins to deposit on the bottom. As the velocity still further decreases, that material deposits still more. So surveys of the river made at different stages of the river and in different years would be very perplexing, and would not indicate at all what had been going on. It is absolutely necessary that comparative surveys should be made at about the same stage of the river, and under the same conditions with respect to rise or fall, in order that reliable comparisons may be made. That is very striking on the Missouri River because the bottom is very soft, yields very readily to the cutting force of the current, and when the flood is at its maximum we get these very great depths, but as soon as the velocity begins to decrease, the deposit commences and the bed fills up.

Q. Then I understand, as a general proposition, Colonel, that the narrowing of the channel, either by levees or by revetment work, or by any other kind of work, on the Missouri and Lower Mississippi, does not have the effect of raising the bed of the river over and above what it would be without any of this narrowing?—A. I think that would have to be qualified a little, there are so many other things that enter into the problem. For instance, if you simply contract the channel at one point, or, say, for a few miles, you might get a very different effect upon the river above, where it is not contracted, than if that contraction had been extended for a considerable distance. I don't know whether I have made myself perfectly clear to you on that or not.

Q. You think it might scour it for a few miles and have a tendency to raise it below or above?—A. It might raise it at some other point. But where you have a very soft, yielding bottom, if the waterway is contracted the general tendency is to scour the bottom.

Examined by Mr. NELSON:

Q. At high water it scours a good deal, and in low water the channel, where the deepening has been going on, is liable to fill up even in that place, isn't it?—A. Yes; but if you take the river where it is, say, a mile wide and contract it to half a mile in width, and then make comparative surveys at the same stage, either at a high or a low stage, you will find a deepening of the bed.

Q. But that channel is apt to be as variable even between high and low water as at other places?—A. Yes, sir; that is, it will scour and fill, but it will be deeper.

Q. Even in the narrow places?—A. Every variation in the velocity of the water makes a variation in the bed of the river, whatever the width.

Q. And when the water is very low, silt is as apt to be deposited there as anywhere?—A. Well, when the water is very low there is very little silt moving. The deposit takes place while the water is going down from its flood height to a lower level. When it gets down to a low-water level there is very little material moving in the river at all, and there is not much change; of course there is some little change going on all the time, but the depth will be greater in the narrower channel than it was in the wider one.

Examined by Mr. BERRY:

Q. Have you done any dredging work on the Missouri?—A. No, sir; we don't dredge there at all.

Mr. BERRY. I believe that is all I care to ask on this subject.

The WITNESS. I would like to show you a map, before you leave the subject of the Missouri River, to show what can be done and what has been done in regulating the river.

(Witness then explained the effect of certain improvements as shown by maps produced before the committee.)

Examined by Mr. NELSON:

Q. What is the length of the reach of the river that you have improved as you have described?—A. About 45 or 46 miles.

Q. And how much have you expended in improving that?—A. That reach has cost somewhere (I couldn't tell exactly) an average of between $40,000 and $44,000 per mile.

Q. For the 45 miles?—A. Yes, sir.

Q. Can you give the points between which that work extends?—A. The work of systematic improvement was begun at a point about 5 miles above Jefferson City, and extended to the mouth of the Gasconade.

Q. A distance of about 45 miles?—A. That is about it.

Q. And it has cost $44,000 a mile?—A. I couldn't tell you the exact cost; somewhere between $40,000 and $44,000.

Q. Now, you speak of improving the river on a different plan at a reduced cost. Will you please describe the difference between the plan you have in view and the plan you have been proceeding upon? You say you expect to reduce it to about 30 per cent; that would be, in round numbers, about $15,000 a mile. Do you expect to reduce it to about $15,000 by your new plan?—A. I would say, rather than "expect," that we hope to. We don't know yet what results we will get from this new system. In the first place, we have been reducing the cost of dike construction, by changing the details, without losing any of the efficiency. But the great reduction of cost that is expected is in the protection of banks; instead of revetting the whole length of a bank, the idea is to hold points of the bank with very heavy work.

Q. Only hold points here and there?—A. Hold detached points. For instance, in a bend we will put in these detached works 3,000 or 4,000 feet apart, instead of revetting the whole length of the bank. We are putting in a number of those, what we call bank heads, this year.

Q. Those are like piers running out into the river?—A. No, sir.

Q. Dikes?—A. No, sir; it is a circular structure. Here is one that was built last spring just before the flood [referring to a blue print].

Q. Can you describe it in some way? What do you call these [indicating] in the first place?—A. Bank heads; put in at intervals along the banks, in bends.

Q. On which side of the bend?—A. On the concave side.

Q. It is a sort of circular pier running out into the river, isn't it?—A. It is a structure with a circular front of somewhere between five and six hundred feet, with very heavy riprapping.

Q. Is it a set of piles that you put in?—A. Well, in this first one [pointing] we put in piles around here and put a very heavy mass of stone in front, but in the newer ones that we are making we are simply putting the stone right into the bank.

Q. It consists, then, in fortifying the banks of the river that are liable to be undermined by the river with piles and stone?—A. Well, these new structures have no piles at all; just a heavy mass of loose stone.

Q. Just a heavy mass of loose stone piled in in front of those places. It is a species of riprapping, then?—A. Yes; it is a heavy riprapping of points in bends.

Q. It may be described, then, as a heavy riprapping of the more prominent and exposed points along the river; that is your new system?—A. That doesn't quite describe it; not the most prominent points, but it is the protecting of the bank in bends where caving has taken place, by very heavy riprapping at detached points around the bends, instead of revetting the whole length of the bend. [Referring to a blue print.] Suppose, for instance, a bank is cutting here. We put in these bank heads, three or four thousand feet apart; instead of riprapping the whole bend, we simply put a very heavy riprapping at certain points. There will be some caving between, you know, but the idea is that it can't go beyond a certain limit and will have to stop.

Q. Well, I suppose that heavy riprapping may form bars there?—A. No; it doesn't form a bar there. It may form a bar below the structure, but in front there is always a scour, and the stone follows down with the scour.

Q. You think, then, by this new method you have started on, and have in mind, that you can reduce the cost to about $15,000 a mile?—A. Well, I wouldn't like to say that, Mr. Senator. I would not like to go further than to say that we hope to reduce the cost very largely. I wouldn't like to set any specific sum as a limit to the reduction, because we can't tell exactly what it will be until we carry the system out far enough to see.

Q. Is there any navigation on this reach of the river that you have improved in the manner you have indicated, at a cost of $44,000 a mile?—A. There is some little navigation there.

Q. Local navigation?—A. Yes, sir.

Q. Local boats that cross here and there—ferryboats?—A. Well, there are boats at Hermann, and there are little boats at Jefferson City that just do a little local trade. During crop season they do quite an extensive business on short runs.

Q. From point to point?—A. Yes; but the Osage and the Gasconade rivers are in this reach.

Q. Neither of them is navigable, is it?—A. Oh, yes; both of them are.

Q. Are they navigable?—A. Yes, sir.

Q. How far is the Osage River navigable?—A. It is navigable at certain stages for (I couldn't say exactly, offhand) over a hundred miles, and in high water up to Osceola, 228 miles.

Q. Are there any boats plying on it?—A. Yes, sir; small boats.

Q. And on the Gasconade?—A. And on the Gasconade, yes.

Examined by Mr. GALLINGER:

Q. Colonel, could you state, offhand, how great an expenditure the scheme of so-called systematic improvements on the Missouri River contemplated?—A. I don't think there was any set sum, because when this work was started the idea was to find out what it would cost and whether it was practicable; it was tentative. The commission has been working along to see what could be done for the radical improvement of the river in this reach, and the result is that in this 45 miles I speak of, where the work is nearly completed, the work has shown that it is entirely practicable to completely control the river and to make perfectly good channels. But it has also shown that the cost was very large, and the commission is now at work to see whether these same results can not be obtained at a very great reduction of cost.

Q. You stated, Colonel, that you had improved 46 miles, at an average cost of $44,000?—A. I think something under that; I couldn't give you the exact figures.

Q. Assuming those figures to be correct, that would be an expenditure of a little over $2,000,000 for the 46 miles. Now, as there is practically no commerce on the river, would you venture to express an opinion as an engineer of experience and a man of observation whether that is a judicious expenditure of money by the Government?—A. At that rate, do you mean?

Q. Yes, sir.—A. I should say it was not.

Q. In other words, unless the cost per mile could be materially reduced it would be your opinion that it was rather a wasteful expenditure of money on the part of the Government, would it?—A. I should say that it was not judicious; that if we can't reduce its cost very materially the systematic improvement of the river is hardly justifiable at this time; it might be at some future time when the country is more fully peopled and there is a larger demand for methods of moving commerce. But I would say this, that no improvement on this river can be expected to bring any material results in the way of developing commerce or to help the people of the valley in the matter of reducing rates until the river is opened out a sufficient length, and especially opened out fully to the mouth, so that boats, for instance, can start from St. Louis and go to some point some distance up the river. The present idea would be, of course, to reach Kansas City. Now, if boats could have certainty of safe navigation from St. Louis to Kansas City upon the Missouri River, I haven't the slightest doubt that boats would be there and that there would be a very considerable commerce developed.

Q. There is a trunk line of railroad on either side of the river, is there not, for a good many miles?—A. Yes, sir.

Q. Let me ask you about this matter of the scouring process in consequence of narrowing the stream. Isn't there a pronounced difference of opinion among engineers on that point, Colonel, as to precisely

what the effect is upon the bed of the river?—A. Yes, sir; I don't think there are very many engineers who know definitely what that effect is upon a river like the Missouri. They know in a general way. But the engineers who have been connected with the work on the Lower Mississippi and the Missouri River have had a great deal of experience in that line, and they know pretty well what is the action.

Q. Colonel, our inquiry contemplates an investigation of the causes of the floods on the Lower Mississippi, and means of diminishing them. Let me ask you if the narrowing of the Missouri on some comprehensive plan, from Kansas City to its mouth, would not tend to increase the flood at the high-water period on the Lower Mississippi.—A. I can only conjecture. My opinion is that the effect would not be very appreciable, would not be very great, because the floods of the Lower Mississippi reach their maximum at the upper end of that lower valley before the flood of the Missouri River reaches there. I have made some study of that question, and have a diagram here that I had prepared for you.

MISSOURI RIVER COMMISSION.

Q. Who constitute the Missouri River Commission?—A. Major Handbury, Corps of Engineers; Major Heuer, Corps of Engineers; Professor Broadhead (who is a civil member), of Columbia, Mo., formerly professor of geology in the university, and Mr. C. L. Chaffee, of Omaha. Captain Chittenden is the secretary and I am president of the commission.

Q. One of the men you have named is a civil engineer, is he not? Doesn't the law require one of the civilians to be a civil engineer?—A. I think Professor Broadhead was appointed under that provision.

Q. How often and where does the commission meet?—A. The commission meets generally in St. Louis when there is any business of such importance as to require their assembling, which is some seasons oftener than at others. For instance, last year we had but one formal meeting, because the work was very largely reduced. The appropriation for the river was cut down to $300,000, and the commission had outlined all of the work that was to be done under that, and there was no further necessity for a meeting. At other times meetings are more frequent, but considerable business is done through correspondence, by sending matter around to the commissioners instead of incurring the expense of a meeting.

Q. In the matter of reducing the cost per mile of these improvements on the Missouri River, that has not yet been demonstrated as feasible, has it, Colonel?—A. We have demonstrated the possibility of reducing very considerably the cost of the dike work—somewhere between 25 and 40 per cent.

Q. And the dike work has been a very considerable amount of the cost?—A. Yes. The reduction in the cost of bank protection has not been fully demonstrated yet by this new work.

Q. Could you make any statement to the committee as to the probable permanency of these improvements? For instance, how long will these improvements you have made on this 46 miles probably last?—A. I don't think these improvements or any river improvement can be expected to last for any considerable length of time without attention from time to time. All the work in this reach will require a certain amount of attention; and the work is not completed in the sense of being in such a condition as to stand the wear and tear now; all of the dikes, for instance, should have additions in order to make them more

permanent, and it is hoped that they can be given a fair degree of permanency.

Q. Well, what would you say as to the permanency of this work as compared with other river work?—A. As it stands now it is not as permanent as work in rivers that have beds in firmer material, but I would say, generally, that all river work has to be attended to from time to time. You can't make any river work so substantial that it will not need attention. We have a very recent illustration of that in the accident on the New York Central Railroad, where the track ran on the bank of the Hudson River, and the embankment was supposed to be and was on solid rock; nevertheless it went into the river. That shows that however permanent an improvement may appear to be, it demands attention at all times.

Q. (By Mr. BERRY.) In your opinion, could anything be done on the Missouri River that would aid in diminishing the floods on the Mississippi River below Cairo?—A. I think not. I don't think any class or method of work that would be feasible upon the Missouri River would have any great effect upon the height of the flood in the lower Mississippi River.

Examined by Mr. NELSON:

Q. The commission is composed of three army officers and two civilians, with an army officer as secretary, who is changed from time to time. Is he in addition to the three army members?—A. Yes, sir; he is not a member, he is the secretary of the commission.

Q. It is composed, then, of three army officers, two civilians (one of whom is required to be a civil engineer), and a secretary detailed from the Army?—A. Yes, sir.

Q. The army members of the commission, including the secretary have no compensation except their salaries as officers of the Army?—A. No, sir.

Q. And their expenses paid?—A. And their expenses in traveling about when on work; yes, sir.

Q. The civilian members receive $2,500 a year each?—A. Yes, sir and their expenses.

Q. You say the commission only met once last year?—A. Yes, sir.

Q. And this year how many times?—A. This year there has been one formal meeting, and then parts of the commission have met on the works two or three times.

Q. A part of the commission?—A. Yes; not the full commission. I was under the impression when I replied to the last question that the full commission had had but one meeting so far this year, but we have had two.

Q. Except at the meetings, do these civilian members take any hand in the work or have anything especially to do with it?—A. No, sir; they have nothing to do with the work except to inspect it, if they choose at any time.

Q. Do they inspect it, as a matter of fact?—A. Yes, they have; not to any very great extent. Last week two of the civilian members were on the work inspecting it, and one of them a month or two ago.

Q. But the charge of the work and the carrying of it on are left to the president and the secretary?—A. I have charge of all the construction work of the commission on the Missouri River, and the secretary has the work on the Osage and Gasconade.

Q. Isn't it a fact that really the administrative business of the commission, carrying on the work and managing and regulating it, and all that, is done by yourself and the secretary?—A. Yes, sir.

Q. And that the work of the other members is merely of a nominal character?—A. Well, not exactly nominal; it is a little more than that. The full commission decides upon where the work shall be done, and upon the general plans, and make inspections more or less frequently.

Q. They meet as a body to decide on where the work is to done?—A. Yes, sir; and allot the appropriations.

Q. Allot the money for the different reaches of the river?—A. Yes, sir.

Q. But beyond that the work is done by the president of the board?—A. The actual construction of the work is done under the direction of the president and the secretary.

Examined by Mr. BERRY:

Q. Could or could not this work on the Missouri River be carried on as efficiently and as effectively by the army officers as by the whole commission? In other words, is there any necessity for these two civilians now on the Missouri River Commission remaining?—A. Well, Mr. Senator, a part of that depends, in the first place, on what was the object in creating the Missouri River Commission. If I understand it right, the idea was to have a body of men take charge of the improvement of this river who should say where the work should be done and how it should be done, and that they were not to be interfered with in that matter. If that idea could be carried out in practice, if the commission could decide upon just what kind of work was best, how it should be done, when it should be done, and where it should be done, without dictation from other people, I think the commission would be a very good thing; that that would be a very good way of administering the affairs of the river.

Q. Without dictation, do you mean, from the Secretary of War or from Congress?—A. No, no; I mean from outsiders. Of course the commission is the creature of Congress. Well, you might say the difficulty is partly in Congress, too. For instance, an appropriation is made for the Missouri River of so much money—a lump sum of money—and it is to be expended at such and such points and in such a manner, within the discretion of the commission. Of course the commission's action must be approved or disapproved by the Chief of Engineers or the Secretary of War. Now, after that appropriation has been made here come in a lot of other provisions—in the first place, that $20,000 may be expended at this point, $40,000 may be expended at that point, $100,000 at some other point. In the last river and harbor act, of July, 1896, there were eight or nine different places specified where certain amounts of money might be expended, and afterwards was added "within the discretion of the commission." But the fact that Congress had mentioned these various places made it appear to the people interested in these places that these appropriations were made direct for those places and must be expended there, and therefore pressure was brought to bear from all sides upon the commission to place this money in these places. Well, to do that in the way the people interested wanted it done would be to break up the whole business of systematic improvement of the river, and in fact it did result in the practical disorganization of systematic improvement. Now, if the work is to go on in that way I don't see that the commission can accomplish anything more than a single officer in charge of the river could do. But if the commission could (as was probably the original intention) have full control of affairs and not be required to do this or that or the other thing with regard to the points at which expenditures should be made and how they should be made, I think it would be a very good thing, because

a commission, even if it doesn't do much work, carries greater weight in a community than one man. For instance, people interested want certain work done here; it is considered by the commission when they make their allotment; they conscientiously go over all these demands and see where the work should be done, where the best place to do it is, and then, when they have given their decision, that ought to be the end of it, and the work ought then to go on.

Q. Then, if I understand you, Colonel, if Congress should simply appropriate a lump sum of money for the improvement of the Missouri River from point to point and leave the matter entirely to the commission, you think it might be well to continue the civil members on the commission, but if Congress is going to undertake to specify where certain parts of the appropriation shall be expended, then the matter can be handled as well by the army officers as by the whole commission as now composed. Is that your answer?—A. Yes, sir; and I would go further than that, and state that if it is the desire of Congress that work be done at any particular points, and they would make their appropriations for those points definitely and not deduct them from the general appropriation made for the general improvement of the river, a great deal more would be accomplished.

Examined by Mr. GALLINGER:

Q. Is it not a fact, Colonel, that when this commission was created it was announced that the purpose was to expend a large amount of money upon this river with a view to having systematic improvements made?—A. I think that was the intention.

Q. And it is likewise a fact that of recent years the appropriations have been very largely reduced beyond the point that was at first contemplated?—A. Yes, sir; in 1896 the appropriation was cut down to $300,000.

Examined by Mr. BERRY:

Q. Do I understand then, Colonel, that it is your opinion that Congress should not specify particular points unless they specify definitely that certain amounts shall be appropriated for those points?—A. Yes, sir; and not take the amounts out of the general appropriation.

Q. And then make appropriation for general improvements outside?—A. Yes, sir; a separate appropriation.

Q. Would those remarks apply to the Lower Mississippi as well as to the Missouri?—A. I think so.

MISSISSIPPI RIVER COMMISSION.

Examined by Mr. NELSON:

Q. Are you a member of the Mississippi River Commission, Colonel?—A. I am.

Q. How long have you been a member of that commission?—A. Since January, 1894.

Q. Have you taken occasion to study the matter of floods on the Mississippi River?—A. Yes, sir; to a certain extent.

Q. About what proportion of water during high stages comes from the Ohio and what proportion comes from the combined Mississippi and Missouri at Cairo?—A. I would say that when the flood is up to its maximum at Cairo almost the entire volume of water comes from the Ohio River. I can show you by a diagram here.

Q. How did the flood of 1897 compare in height with previous floods? Was it higher than any previous flood or was it lower?—A. In some parts of the river it was considerably higher.

Q. I mean at Cairo.—A. At Cairo it was nearly up to the maximum; not quite.

Q. What flood do you call the maximum at Cairo?—A. The flood of 1883, I think.

Q. The 1883 flood was the highest flood?—A. It was the highest at Cairo.

Q. And the flood of 1897 was how much less?—A. It was only a small fraction of a foot less.

Q. Now, at that flood stage last spring what proportion of the water that went to make up that flood at Cairo came from the Ohio and what proportion from the Upper Mississippi and Missouri combined?—A. It would take some computation to reply to that question; but I can say, in general terms, that almost the entire volume of that flood when it was at its maximum at Cairo was from the Ohio River.

Q. Do you remember what time it reached its maximum?—A. Yes, sir; I can give you the day, or within a day or two of it. It was about the 24th of March, or within a day or two of that. By referring to the records I could give it to you exactly.

Q. You mean, then, by your last answer, Colonel, that the Mississippi River at Cairo was at that time in its normal condition—that it was not in a state of flood?—A. You could hardly call it in a state of flood at that time; no, sir. I mean the Mississippi above Cairo not affected by the Ohio.

Q. At about its average normal condition for that season of the year; that is, it was not in what you might call a state of flood?—A. No, sir; it was not in a state of flood.

Q. And what caused the flood (and by that I mean the excess of water over ordinary conditions) was the surplus water in the Ohio at that time?—A. Yes, sir; the great rainfall in the valley of the Ohio and its tributaries.

Q. Pending that flood caused by the Ohio, didn't a flood of some kind supervene from the Mississippi?—A. Yes, sir.

Q. About how long after the flood was rushing in from the Ohio and was at its highest stage was it when the flood of the Mississippi came in?—A. The crest of the flood at Cairo was about the 24th of March. The crest of the flood at St. Louis, which included waters from the Upper Mississippi and the Missouri, was a day or two after the 1st of May. [Referring to a diagram.]

Q. And the crest of the flood at Cairo was in March?—A. I should modify that by saying that there was an inferior crest at St. Louis some time before that; from about the 3d to about the 11th of April there was an inferior crest, and then the water subsided a little, then rose again at St. Louis, so it was at its highest about the first week in May.

Q. That was how long after the first crest of the flood at Cairo from the Ohio?—A. About a month.

Q. During that intervening month did the crest of the flood remain stationary at Cairo, or did it abate any?—A. It abated. By the time of the inferior crest at St. Louis the water at Cairo had subsided something over 3 feet. A diagram I have here shows the amount of water that passed Cairo, and the time; also the amount of water and the time of its passing at Paducah, on the Ohio River; at St. Louis, on the Mississippi, and at Grafton, on the Mississippi, just above the mouth of the Missouri, and which shows the upper Mississippi alone, and at St. Charles, on the Missouri, which shows the Missouri alone. A casual glance at this diagram will show you the difference in volume.

Q. Now, that shows you five important points, doesn't it? It shows the crest of the flood on the Ohio simply at Paducah?—A. Yes, sir.

Q. And the crest of the flood at St. Louis of the combined streams, and the crest of the flood on the Missouri at St. Charles, and the crest of the flood on the Mississippi at Grafton, and the crest of the combined flood at Cairo?—A. Yes.

Q. At what time did the flood attain its highest stage at Paducah, on the Ohio?—A. Just about the same time as at Cairo—about the 24th of March.

Q. How high was it then as compared with the highest of previous floods?—A. It was very nearly up to maximum.

Q. Very near up to the highest flood, that of 1883?—A. Yes, sir.

Q. And that flood was caused by a big rainfall in the valley of the Ohio and its chief tributaries?—A. Yes, sir.

Q. The Tennessee and the Cumberland.—A. Yes; and the Allegheny and the Monongahela and the Muskingum.

Q. Yes; all those big streams. Now, the crest of the flood at St. Louis was in the first week in May?—A. Well, that was the superior crest.

Q. There was an earlier crest some time before that?—A. Yes, sir.

Q. When was the crest of the flood at St. Charles on the Missouri?—A. There were two crests there in the spring; one about the 10th of April and the other about the 1st of May.

Q. And when the upper Mississippi at Grafton?—A. There were two crests there, one about the 5th of April and the other about the 3d of May. I would like to say right here that in giving these dates I am taking them from the diagram; I haven't the gauge readings before me, and I may be in error a day or two.

Examined by Mr. BERRY:

Q. In regard to these different heights on the lower river, is that all set out in the report of the Mississippi River Commission made this year?—A. All the gauge readings are given; yes.

Q. And a comparison is made with former years?—A. Yes, sir.

Examined by Mr. NELSON:

Q. In this statement made by you, Colonel, it would seem that the flood of the upper Mississippi and that of the Missouri came at about the same time; they came in April at about the same time, and one was the 1st and the other the 3d of May?—A. Yes, sir.

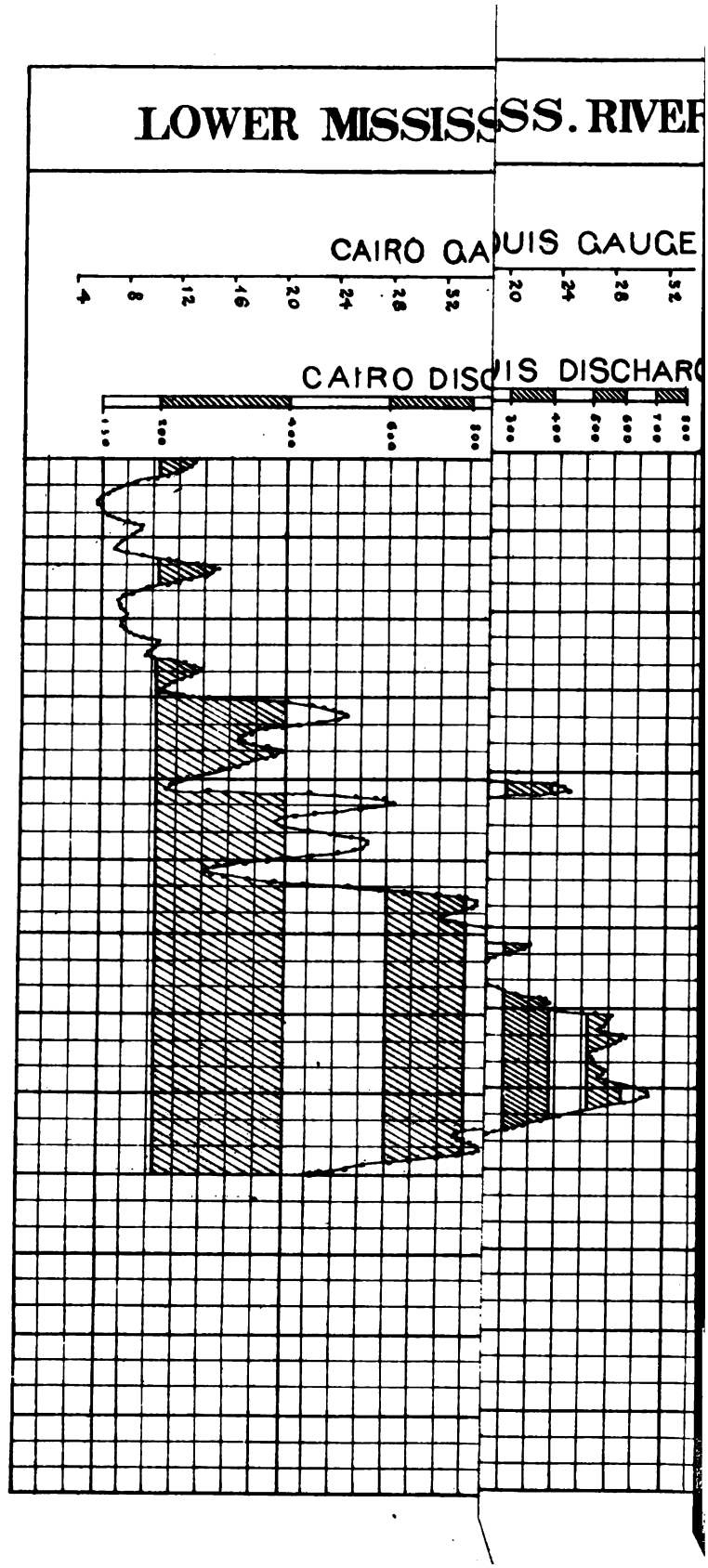
Q. So those two floods of the Missouri and Mississippi occurred at the same time, practically?—A. Yes, practically.

Q. And they were the result partly of rains and partly of melting snows at the head waters of the Missouri and the Mississippi?—A. I think they were largely the result of rains. The melted snow cuts a very small figure when you consider that 12 inches of snow makes only 1 inch of water. Of course, if a very large quantity of melted snow comes in with very hard rains, it appreciably swells the volume.

Q. After the flood caused by the Ohio had been going on for about a month and had gradually diminished to the extent of about 3 feet, then this flood from the combined Missouri and upper Mississippi intervened, and that prolonged and continued the flood, didn't it?—A. I think there is no question about that.

Q. How long did the flood continue at Cairo?—A. The flood above the banks at Cairo (which would take it about 40 feet above low water) continued about sixty days; from the 1st of March until the end of April—about the 29th, I think.

Q. And after that it subsided?—A. After it passed the bank it went down quite rapidly.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IS DISCHARG

Q. In your office what gauge do you call flood stage at St. Louis; about 30 feet?—A. Thirty feet would be a good flood stage at St. Louis; that wouldn't be an extraordinary flood. This flood didn't reach 30 feet, except when at its highest crest.

Q. At what time was that?—A. That was in May. It was up there about five days.

Q. Well, that was after the flood had subsided at Cairo?—A. Yes. The flood at that time had gone below the banks at Cairo. But you see they had part of this St. Louis flood before that, but not up to that extreme height.

Q. When had it attained a high enough stage to be a factor in the flood below?—A. About the 2d of April.

Q. Then it was at the beginning of the second month of the flood at Cairo that it supervened?—A. Yes; and it reached that first crest at St. Louis after the fall from the crest at Cairo.

Q. How long did the flood continue at St. Louis from the time the water first got to be at a flood stage until it dropped off?—A. It continued about a month; perhaps two or three days more.

Q. So really it continued until the flood subsided at Cairo?—A. Well, it continued for quite a time after the flood had gotten within the banks at Cairo.

Q. How did the flood stages compare at St. Charles and Grafton on the Mississippi?—A. They were comparable with the St. Louis flood.

Q. Both of them?—A. Yes; you might say that in general terms.

Q. So they kept on, side by side?—A. Just about the same dates.

Q. Then, to summarize the flood at Cairo, you would say it was caused in the first instance almost entirely by the Ohio River?—A. Yes, sir.

Q. But that it was prolonged by the floods of the Mississippi and Missouri combined?—A. Well, I would put it in this way: It was prolonged by the flood of the Mississippi and Missouri, but its maximum height was not caused by those rivers.

Q. The maximum height was attained before the floods from those streams supervened?—A. Yes, sir.

Q. And all they did was to prolong it?—A. To lessen the rate of subsidence of the flood.

Q. To prolong it?—A. Yes. I would say the gist of the whole thing lies right here in this little table that I have put at the foot of this blue print.

Witness produced to the committee the following blue print, marked Exhibit I:

Q. What conclusion do you come to in regard to the flood of last spring from the data shown on Exhibit I?—A. Our computation shows that the quantity of water that passed Cairo during the days the river was above its banks would fill a lake 8,022½ miles in area 10 feet deep; not the water that passed Cairo, but the water that passed above the banks of the river. The conclusion I come to from that is that it would be absolutely impossible to impound that water in any reservoir it would be practicable to build.

Q. Are there any points on the Ohio River or its chief tributaries (like the Cumberland, the Tennessee, the Allegheny, or the Muskingum) where you could find good holding grounds where reservoirs could be built large enough to have a material effect in diminishing the floods of the Ohio at high water?—A. No, sir; I think not; that is to diminish the floods sufficiently to make levees unnecessary on the lower Mississippi.

Q. And that could be built within reasonable bounds of expense?—

A. I think it would be impossible to find an area large enough and with a sufficient depth to impound enough water to make a very great difference in the flood level at Cairo to bring it below the top of the natural banks.

Q. Your opinion is, then, that the Mississippi River could not be materially relieved from the floods of the Ohio by reservoirs constructed on the Ohio or its tributaries?—A. I think not, by any reservoirs that would be practicable, and at anything like a reasonable cost.

Q. Now, when you proceed down below Cairo, the next factor that supervenes is the St. Francis River, isn't it?—A. Yes, sir.

Q. Please state how far it is from Cairo to the point where the waters of the St. Francis River debouch into the Mississippi. Doesn't it go into the Mississippi River in the shape of a delta, or does it go in a well-defined channel?—A. It goes in a pretty well defined channel. That comes in just above Helena.

Q. It flows parallel with the Mississippi for quite a distance, doesn't it?—A. Nearly so, yes.

Q. With no high intervening bluffs?—A. No very high land at the lower end.

Q. So that at high water, when it overflows, the water goes into the Mississippi away above the mouth of the St. Francis, doesn't it?—A. There is high land intervening on the upper part of the reach, from Cairo down to New Madrid. Below that the land is low and subject to overflow.

Q. So that at high water the St. Francis pours over into the Mississippi, or into the Mississippi bottoms?—A. Well, that depends. There are conditions under which the water can come out of the St. Francis, over the lowlands, into the Mississippi; but that would not be at the crest of the flood in the Mississippi. At the crest of the flood the Mississippi would be higher than the water in the St. Francis.

Q. You don't understand me, I think.

Mr. BERRY. On the upper part the Mississippi runs into the St. Francis, rather than the St. Francis into the Mississippi. I mean, where there is a break above, the Mississippi River water runs into the St. Francis basin.

Mr. NELSON. Yes, if the Mississippi breaks through its levees. But what I am driving at now is, assuming that the Mississippi doesn't break over or through the levees, and that the St. Francis is at a flood stage, isn't there a considerable distance along the St. Francis River where the land between the two rivers is so low that the St. Francis would overflow and flood the Mississippi bottoms above the mouth of the St. Francis?

The WITNESS. The Mississippi sometimes backs up into the St. Francis and overflows the bottoms there, but the volume of the St. Francis River is not very large and it does not of itself add a great deal of water to the Mississippi River floods.

Q. Was there a flood in the St. Francis River last spring?—A. Yes, sir.

Q. Did that cut any figure in the flood below Cairo?—A. Very little, except by the water that was added to the St. Francis by the breaks above in the Mississippi levees.

Q. Oh, the Mississippi broke its levees and went into the St. Francis between Cairo and New Madrid?—A. Yes, sir; the water went in there and down below there.

Q. What is the distance from Cairo to New Madrid?—A. About 70 miles.

Q. Was the White River in a state of flood last spring?—A. Not a very large flood.

Q. And the flood of that river didn't cut any figure?—A. Well, it cut some figure. Of course it added some water.

Q. How did the stages of water compare at the mouth of the St. Francis, or right below that and the mouth of the White River, with the stage at Cairo—was it higher or lower?—A. I think the range from low water to flood level was a little lower than it was at Cairo.

Q. Then, whatever flood there was in the St. Francis River last spring had do material effect upon the flood in the Mississippi?—A. I don't know that I would put it quite as strong as that. Well, I don't know but that would be about right, too—to say that it didn't have any material bearing on the height of the flood.

Q. Either upon the height or duration of the flood?—A. Well, it had a bearing on the duration of the flood, from the fact that the flood of the Mississippi went into the St. Francis. Water from its own watershed wouldn't have any very great effect, but the water that went into it from the Mississippi did.

Q. But whatever bearing it had was to relieve the Mississippi partially, wasn't it—for a certain reach of the river?—A. Up near Cairo?

Q. Yes.—A. Yes; it would relieve it a little there.

Q. It would naturally relieve it some between the place where it went out and where it went in again?—A. Yes.

Q. Now, the next tributary down the Mississippi is the White River, isn't it?—A. Yes.

Q. The White and the Arkansas rivers come in so close together that it would be the combined streams that would affect the Mississippi, if at all?—A. Yes.

Q. Were the White and Arkansas rivers in a state of flood last spring?—A. They were in a state of flood, but not excessive flood.

Q. Did the waters from those rivers have any material bearing upon the flood of the Mississippi River?—A. The water from those rivers does have a bearing, of course.

Q. I mean, did it last spring either tend to increase the high water or to prolong the flood?—A. Of course they added that much to the flood conditions down below.

Q. Have you any statistics or figures that would show us what figure, if any, the flood in the combined river cut last spring, and what bearing it had upon the flood in the Mississippi River?—A. Yes; the gauge readings of the Mississippi River and tributaries show that. They show the heights of the floods in the tributaries.

Q. Have you any recollection as to when the floods from the White and Arkansas rivers supervened? Did they come in at the same time as the flood from the Ohio?—A. The exact time of their maximum flood I do not remember. That could be gotten from the records. But, of course, at that season of the year those rivers are always what you might call in a state of flood; they are high. In some years they are very much higher than in other years at the time the Mississippi flood is passing.

Q. Have you any data which would go to show how much the floods in the St. Francis and in the White and Arkansas combined added to the flood of the Mississippi (and by that I mean the excess of water over normal conditions)?—A. The computation of discharge, do you mean?

Q. Yes. Can you make a comparison similar to the one you made a short time ago in regard to the water at Cairo, when you spoke of the

size of the lake that would be formed?—A. I don't think any computation of that has been made, though I think it is very probable the secretary of the commission could give you from the records about what the computation of discharge would be for those rivers at the stages that existed at the time of the passage of the flood.

Q. Could you furnish us a statement showing the condition of the floods in these rivers (the tributary streams) during the continuance of the flood at Cairo (that continued about sixty days, you know); how they compared with normal conditions and how long they continued? What I want to find out is what bearing, if any, the floods of those rivers had upon the Mississippi?—A. I understand your object, and I would say that I haven't any records here, but that what you desire could be given to you very fully, for all of the rivers, from the office of the secretary of the commission.

Q. Very well. Will you get him to supply us with that, Colonel?—A. Yes, sir.

Witness submitted (on the point last referred to) the following statement, marked Exhibit J:

EXHIBIT J.

WHITE RIVER.

Gauge at Clarendon, Ark., 134 miles above mouth:	
Highest stage recorded since 1871—March, 1890	36.6
Stage when crest of Mississippi flood passed mouth of White River, March 29, 1897	31.8
Average stage of Clarendon gauge for 10 days preceding March 29, 1897	30.2
Average stage of Clarendon gauge for 32 days succeeding March 29, 1897	31.5

ARKANSAS RIVER.

Gauge at Little Rock, Ark., 176 miles above mouth:	
Highest stage recorded since 1871—May, 1892	31.2
Stage when crest of Mississippi flood passed mouth of White River, March 29, 1897	13.0
Average stage of Little Rock gauge for 10 days preceding March 29, 1897	19.8
Average stage of Little Rock gauge for 32 days succeeding March 29, 1897	12.1

ST. FRANCIS RIVER.

(Gauge at railroad bridge, 194 miles above mouth.)

The stage at this gauge, the only one maintained on the river, was entirely controlled by the Mississippi River during the flood of 1897, and no comparison is possible. The stage in the upper St. Francis is known to have been not a high one.

Q. The next great basin is the Yazoo Basin, isn't it?—A. Yes, sir.

Q. That is on the east side of the river?—A. That is on the Mississippi side.

Q. Does that perceptibly increase the floods of the Mississippi?—A. The discharge of that river alone, without the overflow from the Mississippi, doesn't have any very great effect on the floods.

Q. Now, as I understand it, between Cairo and Vicksburg there are what you might call three river basins or bottoms (I am speaking now of the river as it would have been without the construction of the levees), the St. Francis River Basin, the White and Arkansas Basin, and the Yazoo Basin?—A. Yes, sir, and part of the Tensas Basin.

Q. Recent levee work has been all in the direction of closing these basins, has it not—closing up the fronts of the basins?—A. Yes, sir.

Q. Those basins, in their natural conditions, afforded great natural holding grounds for surplus water of the Mississippi River at high

water, did they not?—A. They did in one sense. They absorbed a good deal of the overflow water, but they gave it out again into the Mississippi lower down.

Q. I know; but for the time being the water naturally flowing out and spreading, as it would, over these basins diminished the water in the river and naturally relieved the Mississippi for a great deal below?—A. Yes, sir.

Q. Now, as I understand it, the recent levee work has been all in the direction of closing those basins, without regard to the breaks or crevasses that occurred last spring?—A. Yes, sir.

Q. The work on the Yazoo Basin has been completed, practically; that has been closed, hasn't it? I mean aside from the crevasses that have occurred.—A. Yes, that is entirely closed, except for a short distance at the foot.

Q. And so with the White River Basin?—A. The White River Basin is not entirely closed; a great deal of it is.

Q. And the basin of the St. Francis River hasn't been closed altogether?—A. No, sir.

Q. It has been partially closed?—A. Yes, sir.

Q. Have you any idea how big these natural basins or holding grounds were at these points before they were fenced out by the levees?—A. Yes, sir; that is a matter of record.

Q. Would you give us those figures?—A. The areas of the different basins?

Q. What would have been the natural flood basin or natural holding ground of the St. Francis River Basin? What would that have contained for the time being if it hadn't been penned out by levees, and the same as to the White and Arkansas Basin, and the same as to the Yazoo Basin? In other words, how big an area has been fenced out by the levees?—A. We have that.

Q. Will you give us those figures, so they may be inserted in the record?—A. Yes, sir.

Complying with the last question, witness submitted the following statement, marked Exhibit K:

EXHIBIT K.

Areas of Mississippi River basins.

	Square miles.
St. Francis	6,706
Yazoo	6,648
White River	956
Tensas	5,370

Q. Isn't it a fact that the inclosure of these basins I have spoken of by levees (fencing them out, you might say) has tended to aggravate and increase the floods of the Mississippi River at and below those points?—A. It has unquestionably raised the flood level; yes, sir.

Q. And prolonged it?—A. I wouldn't say that it has prolonged the flood.

Q. At high stage, I mean.—A. Of course the height of the floods has been increased, but the velocity of the water in the leveed part of the river is very much greater than it is where it overflows land; therefore the total volume of water passes more rapidly.

Q. Well, what I mean is this: Take the great volume of water that comes down during the floods. Instead of the river having all those basins for the water to go into, as it used to have at high water, it is confined to a narrower channel. Hasn't that had the effect of materi-

ally aggravating the height of the floods?—A. It has considerably increased the height; yes, sir.

Q. There is another basin below the Yazoo, isn't there?—A. Yes, sir; there are a number of basins below. There is the Tensas Basin.

Q. That is not entirely fenced off, is it?—A. Yes, sir; all except a small portion at the very lower end of it.

Q. Where does that go into the Mississippi—near the mouth of the Red River?—A. The Red River is the foot of the Tensas Basin.

Q. And except down at the lower end there of the Tensas Basin, that has been fenced off?—A. Entirely leveed, from the Arkansas River down to within a few miles of the mouth of the Red.

Q. Do you think it is wise to entirely close up the balance of these basins—the St. Francis Basin, for instance, and the White? I understand there is a lot of that that is not closed. Is that correct?—A. Yes, sir.

Q. Do you think it is wise to entirely close this up until the levees are raised or made high enough?—A. I do not. I think the levees below should be raised high enough to take the maximum flood before any further closure of the upper basin is undertaken.

Q. That opinion, then, amounts to an absolute demonstration of the fact that the closure of these basins has aggravated and increased the floods?—A. There is no question about its increasing the flood heights. Our gauge records show that when a basin is closed the floods rise higher in some parts of the river. That we expect and count upon.

Q. Now, coming back to the reservoir plan that has been discussed, and about which we are directed to inquire, if relief could have been given to the Mississippi River by means of reservoirs, would not the most practical places have been in such a basin, for instance, as the St. Francis River Basin, where there is a large area for a holding ground? Wouldn't that have been the point to have used a reservoir system with effect, if anywhere?—A. Those basins would be the only possible basins, in my opinion, that could be used for the Lower Mississippi River, but to use them for such purposes would destroy them for any other purpose, and the cost would be excessive.

Q. On the reservoir idea?—A. Yes, sir.

Examined by Mr. GALLINGER:

Q. I would like to ask, at that point, whether the construction of an extensive reservoir at the point named would not necessarily overflow a large area of valuable land?—A. Yes, sir; undoubtedly.

Q. And thus become a great charge to the Government?—A. It would overflow a very large tract of arable land. In some of those basins in some of the floods the overflow would last for such a length of time that it would be impracticable to put in crops after the passage of the flood; but that is not always the case now, with their outlets open.

Examined by Mr. NELSON:

Q. Going down the Mississippi from the mouth of the Tensas Bayou are there any basins that have been fenced in by levees?—A. From the Red River down, on both sides of the river, with some small exceptions, the levees are continuous; down to Baton Rouge on the left bank the bluffs are near the river and there are no levees.

Q. There is some high land on the east side for a section.—A. And there are some comparatively small areas in there that are not leveed; but from Baton Rouge down on the left bank it is all leveed, and from the Red River down on the right bank it is all leveed nearly to the Head of the Passes; and the levees on that part of the river generally are very close to the river bank.

Q. Where did the principal crevasses occur in the river below Cairo this last flood?—A. There were quite a number of crevasses.
Q. Give it by fronts or basins; give us a statement of where the differ-it crevasses occurred?—A. There were in the St. Francis front thir-en crevasses, having an aggregate length of about 2½ miles, which was out 2 per cent of the constructed line of levee.
Q. Well, which one of those thirteen was the most serious crevasse?—. Just below Caruthersville, I think.
Q. From what causes did those crevasses occur? What defects were ere in the levees?—A. Insufficient height.
Q. Those crevasses or breaks in the levees occurred because they were t high enough?—A. Yes, sir.
Q. In every case?—A. I think in every case along that front, if I member right.
Q. How much did they lack of having sufficient height?—A. I would ve to go to the records for that, but I think they lacked in some aces 3 or 4 feet.
Q. What I mean is this: How much would the levees have to be ised in front of the St. Francis Basin to make them a safeguard ainst floods like those of last spring? If you had the job to build a ree there that would protect against floods like that, how much higher uld you build it?—A. The levees were of varying heights, some parts re higher than others. The commission has made an effort to have mputed what height the levees would have to be brought to to make e whole line safe from Cairo to the Gulf. That was in a report of the mmittee on levees (I was a member of that committee) in the annual port of the commission.
Q. Well, to summarize, Colonel, for the purposes of the record, these eaches or crevasses occurred because the levees were of insufficient ight?—A. Yes, sir.
Q. And in order to make those levees a protection to the St. Francis iver basin there would have to be a general increase in height along e whole levee?—A. Yes, sir.
Q. Varying at different points?—A. Yes, sir.
Q. But the whole levee would have to be reconstructed, rebuilt, or creased?—A. Increased in height.
Q. Going down, the next front in order would be the White River out.—A. The next we take here is the Upper Yazoo. That commences Memphis, on the Mississippi side.
Q. How far down does that basin extend?—A. It goes down to about olivar County, I think. The Upper Yazoo levee district is about 124 iles along the river from Memphis down.
Q. In that levee district how many crevasses or breaks were there the levee?—A. There was but one break in that line.
Q. And what was that from? Insufficient height, or some other defect the levee?—A. Insufficient height. I am not certain whether the ater there actually went over the levee or whether the levee sloughed account of the water being right up at the top, you know.
Q. The water need not entirely wash over it in order to damage it, it can come so near the top that it destroys it, so it is about the me?—A. Yes. Insufficient height or size of levee; that is it.
Q. Insufficient height or size, one of those causes. Which comes xt, the White River Basin or the Lower Yazoo?—A. The next is the hite River.
Q. What is the length of that basin?—A. That basin has practically miles of levee.

Q. And how many crevasses or breaks were there there?—A. There were fourteen in that line.

Q. And from what causes did they arise, aside from the high water?—A. Insufficient size of levees.

Q. Insufficient height?—A. Generally insufficient height; yes.

Q. I would like you to distinguish between a levee too weak because of not being thick enough—— A. Not wide enough base?

Q. Yes; and a levee that simply lacks in height.—A. In one case it is overtopped, and in the other case the rear of the levee sloughs away from being saturated with water.

Q. Now, as to these crevasses here—what did they arise from?—A. In this White River Basin I think almost all from insufficient height. The record here says "there were 14 breaks in this line during the flood, being equal to about 3 miles. This line of levee was not up to the same grade as the levees of the Lower Yazoo district on the opposite side of the river, nor were they in as good condition to withstand the flood." So they were low as compared with the levees on the other side of the river.

Q. Too low?—A. Yes; too low.

Q. That was their great defect?—A. Yes, sir.

Q. With the possible exception, then, of this crevasse on the Upper Yazoo Basin, all the others resulted from insufficient height?—A. Yes; and I am not positive about that one. I could find that from the records.

Q. That would have been from one of the two causes—too weak or too low?—A. Yes; you may say with regard to all of these that it was from insufficient size of the levee, either in the height or in the cross section.

Q. How as to the Lower Yazoo Basin; how long is that?—A. The levee lines in this district are 186 miles. Five crevasses took place in this district; one of them was due to a heavy windstorm which caused giving way by wave action, and, as far as known, the other breaks were due to sloughs or defects in the body of the levee.

Q. Weak levees?—A. Yes. The water didn't go over those, but——

Q. They were high enough, but there were other defects?—A. They were not high enough, but they were so high that the water didn't get over them. They ought to have been higher, but still they were high enough so the water didn't get over them.

Q. They gave way because of other weaknesses?—A. Yes.

Examined by Mr. BERRY:

Q. Colonel, about what is the proper width for the base of a levee, and the proper height of a levee, along the Lower Mississippi? I understand it varies with different localities, but I want to know in a general way; what is the general width at the bottom and how does it slope up to the top, and how high does it go?—A. The manner of the construction of levees varies in different localities, not only on account of circumstances requiring varying heights, but on account of the various soils of which they are composed and the ground on which a levee is built. Where there is a good soil, at a moderate height, a good levee would be 8 feet wide on top (the crown), with front and rear slopes of 1 on 3; that is, for every vertical foot you would go out 3 feet horizontally. The width of the base would be for an ordinary levee (I mean by that a levee not of very great height, in good soil) six times the height plus the width of the crown. The width of the crown is usually about 8 feet.

Q. I want to get at it, Colonel, so an ordinary man can understand it, and so I could explain it to him in Congress if he should ask me how

wide a proper levee should be at the base, and what should be the proper height, and what should be the width on top.—A. For an ordinary levee, on good ground, the height of the levee should be at least 2 feet above the extreme height to which the flood is expected to attain. You must have at least 2 feet for safety. Then the width of the base should be at least six times the height of the levee plus the width of the crown.

Q. Well, that still doesn't answer what I want to know so I could tell a man if he asked me how a levee should be constructed. Take a levee in the Upper Yazoo district, the one that broke there. To make an efficient levee there, one that would keep the water out, how broad should it be at the bottom?

Mr. NELSON. At that particular point.

A. Well, that would vary with the height.

Q. Well, I am going to ask you how high it should be afterwards. I want to know how broad and how high it should be, and how wide on top.—A. The height of the levee depends on how high the bank is. If the flood goes over the bank 5, 10, or 15 feet, the levee has to be that much higher than the bank.

Q. Well, I mean from the place you start to build it on the ground, whether it is on a bluff or any other place; how high are the highest of those?—A. I think some of those levees are as much as 30 feet high.

Q. Now, take a 30-foot levee, what would be the width of it at the bottom?—A. The width at the bottom of a 30 foot levee would be probably over 200 feet, because when levees are as high as that they are usually built with a banquette behind them—that is, a reinforcement to the base. A 30-foot levee would be over 200 feet in width at the base.

Q. And how wide on top?—A. A levee of that height would be made probably 15 feet wide on top.

Q. But that is an unusual height for a levee?—A. An unusual height for a levee.

Q. What is the usual height?—A. They vary all the way from 2 or 3 feet to a maximum of, say, 30 feet. I suppose the average height of levees, taking them all together, would probably be somewhere between 6 and 10 feet.

Q. And of a 10-foot levee the width would be what?—A. The width would be 68 feet at the bottom; 6 times the height plus 8 feet, width of crown.

Examined by Mr. GALLINGER:

Q. In your opinion, are the levee improvements on the Lower Mississippi necessary to the interests of commerce?—A. In some respects they are, and in others they are not absolutely necessary.

Q. Suppose the entire levee system should be destroyed, wouldn't the Lower Mississippi River still be navigable?—A. Yes, sir; it would be navigable except at very low stages at some points, just as it is not navigable now.

Q. Then the levee system has very little to do with the navigation of the river?—A. I don't think it has a great deal to do with improving it. I think it has some effect. I think the effect of the levees is to a certain extent to confine the water to the usual waterway of the river, and in that way it has some scouring effect upon the bottom of the river; and while it has that effect it also has a scouring effect on the sides of the banks. And the leveeing of the river contributes to a certain extent to the maintaining of the channels, but I think that effect is largely counteracted by the river wandering around in its bed, attacking its banks, tearing them down and piling them up in the river,

so that much of the great trouble in the navigation of the river is the material that is brought into it largely from its own banks.

Q. The scouring effect upon the banks is detrimental, is it not, to navigation?—A. Yes, sir; the caving or cutting out of the banks is detrimental.

Q. Have you paid sufficient attention to the matter to be willing to express an opinion concerning the scheme advocated by some to remedy the flood conditions of the Lower Mississippi River by the so-called outlet system?—A. Yes, sir; I have given that matter consideration.

Q. And what is your opinion on that point?—A. That it is utterly futile.

Q. Would an artificial outlet soon be clogged, necessarily, by the silt that would be carried into it?—A. It would very soon deteriorate the river below the outlet by the deposit of sediment. The artificial outlet itself would deteriorate, too, as is shown at the passes at the mouth of the river.

Q. And wouldn't there be great danger (taking, for instance, the point above New Orleans that has been talked about, where the outlet could be made to pass through Lakes Borgne and Pontchartrain) of diverting the channel so as to destroy the natural bed of the river entirely or to deteriorate it to such an extent as to make it practically useless?—A. It would deteriorate it, undoubtedly. That effect has been shown beyond any question by surveys made below crevassess. Where there have been crevasses there has been shown to be deposits in the bed of the river, and when those crevasses have been closed up those deposits have been swept away. It is an effect produced by the lowering of the velocity due to the drawing off of water at an outlet. If you lower the velocity there will unquestionably (without any doubt whatever) be a deposit below the point where you lower the velocity.

Q. Then in your opinion, Colonel, an attempt to remedy the flood conditions in that way would not only be futile, but in a sense disastrous to the river itself?—A. Yes, sir; that is my opinion.

Examined by Mr. BERRY:

Q. Colonel (if I understood your answer to Senator Nelson), these levees tend to keep the river in its natural channel in a way that would not occur if the levees were entirely destroyed?—A. They keep the flow of water in the natural waterway to a great extent—that is, they prevent the water from going broadcast over the country, and in that way they produce a scouring effect in the bed of the river to a certain extent.

Q. Do you think that with a properly constructed levee system the water could be confined and controlled in the Lower Mississippi River?—A. You mean a levee system that would keep the flood volume within the river?

Q. Yes.—A. Undoubtedly, sir. I do not think there is any question about it at all.

Q. Do you think that could be done at a cost within $20,000,000?—A. That is about the estimate made by the Mississippi River Commission. That is approximate, of course.

Mr. GALLINGER. Would that include the cost of the levees already built?

The WITNESS. No; that is additional.

Q. An additional cost of $20,000,000. A large part of these levees were constructed by the States or counties or local authorities, were they not?—A. Yes, sir.

Q. Of Louisiana, Mississippi, and Arkansas?—A. Yes, sir.

Q. A large part was constructed by money contributed either by the States or by the levee districts?—A. A very large part of it.

Q. Colonel, I want to ask you if the breaks that occurred in the levees in the flood of 1897 were principally in the levees constructed by the States or in the Government levees?—A. Very little in the Government part.

Q. Senator Gallinger said, I think, that if the levees were all destroyed it would not materially interfere with navigation. I would ask you, if all those levees were destroyed, if it wouldn't materially interfere with anything to navigate, in the way of products, in that country?—A. Very decidedly. It would interfere with the commerce of the river.

Q. It would destroy a large portion of the alluvial lands of the Mississippi bottoms, wouldn't it?—A. Yes, sir. That is, it would interfere with cultivating them. I think it would have a decided effect upon the commerce of the river.

Q. Immediately below where a crevasse occurs there is a deposit which tends to obstruct navigation, isn't there?—A. It doesn't always tend to obstruct navigation, but it lessens the area of flow and helps to diminish the flow.

Q. And makes a deposit of silt or sand; or whatever it may be?—A. Causes a deposit and makes a smaller waterway for the water to pass through.

Q. In your opinion, until the levees are properly constructed below it would not be for the best to close the St. Francis Basin?—A. That is my opinion; yes, sir.

Mr. NELSON. And so with the White River Basin, too?

Mr. BERRY. The White River Basin is already closed, practically.

Mr. NELSON. All of it?

The WITNESS. It was nearly closed, but there are a good many breaks in it now; they haven't been able yet to build it up high enough.

Q. But with a levee system properly constructed you think the St. Francis Basin could be closed and the water confined within the levees?—A. I don't think there is any question about the practicability of building levees high enough and strong enough to carry the greatest flood that ever passed down the Mississippi River.

Q. With an estimated cost of $20,000,000?—A. Yes; approximately.

Q. How long would it take, if the appropriations were ample to let the commission employ all the labor it could, to complete that system of levees?—A. That is a pretty hard question to answer. Where you have plenty of money you can do almost anything, and you can do it in a pretty short time. But in levee building, where you do a very great amount of work, you have to collect together a number of contractors, and they have got to get their plants and their men, and they have got to know beforehand that they are going to have a sufficient quantity of work to pay them to get together a large plant. It is almost impossible to say how many men could be put to work building levees if the money was all available, but certainly they would do a tremendous amount of work in a year. They couldn't build that whole system in a year, I don't suppose; probably in three or four years they might do it.

Q. If the commission had the entire amount of $20,000,000 at their disposal you think it could be completed within three or four years?—A. I think it could; yes, sir.

Examined by Mr. GALLINGER:

Q. Colonel, does that system of leveeing the river at an approximate cost of $20,000,000 involve the rebuilding or reconstruction of these

inefficient levees that the States have built?—A. Yes; it means the completion of the system from the present condition to a condition that we believe would be sufficient to take the largest flood.

Q. Isn't it safe to assume that that estimate (which at best must be approximate) might, as a matter of fact, be largely exceeded?—A. I should say, from the experience gained in the flood of 1897, which gave us a great deal of valuable information in regard to the slopes, that that estimate (which was made before that flood) is a pretty close one. I don't believe it would be very largely exceeded unless the cost of doing the work should largely exceed the cost at which the work has been done heretofore. But if a great deal of work was provided for it is probable that the cost would not be increased, but might be decreased.

Q. Is there greater difficulty now and greater expense in procuring material for the construction of those slopes than formerly?—A. No, sir. Our experience has been that as great quantities of that kind of work was done the cost gradually decreased. When the Government first commenced building levees (and I was on the lower river, in 1883) we used to consider that 20 cents a cubic yard was not at all an unreasonable price. Now a great deal of the work is built at as low a price as 10 cents a yard, and some even as low as 7 cents. I don't know how the contractors live at that price, but they have done the work at that price.

Examined by Mr. NELSON:

Q. This estimate of $20,000,000 was made before this last flood?—A. Yes, sir.

Q. Didn't that flood create such a number of crevasses that have not yet been filled that it would naturally increase the cost a great deal?—A. To close those crevasses would take but a very small proportion of that amount.

Q. What crevasses were there, if any, below the Lower Yazoo Basin?—A. There was quite a large one just below Vicksburg, on the other side of the river, called the Biggs Crevasse, and two smaller ones.

Q. That was in the Tensas Basin?—A. In the Tensas Basin.

Q. Was that owing to too low or too weak a levee?—A. I think the Biggs Levee gave way from sloughing of the bank; insufficient size, at all events.

Q. Going down the river, where was the next crevasse? Was there any below the Red River?—A. Not until after the crest of the flood had passed, but after the crest of the flood there was a crevasse near Baton Rouge, on the west side, that was closed up.

Q. That was the only crevasse below the Red River?—A. Yes.

Q. And that was closed up so it didn't do any material damage?—A. Yes.

Q. Now, there are people who claim the floods could be relieved against by the outlet system. Isn't it a fact that the outlet system is not a practical question at any point above the mouth of the Red River? I mean you couldn't very well, at a reasonable cost, make an outlet above that point.—A. No, sir; nothing that would amount to anything.

Q. So that any outlet system that you think would be practicable could not have relieved against the damages caused by the flood of 1897?—A. No, sir.

Q. Nearly all, with the exception of that Biggs Crevasse—I don't mean the little ones, but all the other crevasses of the flood of 1897—

occurred at points higher than could possibly be relieved by any reasonable or practicable outlet system?—A. Yes, sir.

Q. The first point where you could have an outlet system that would be reasonable or possible would be the Atchafalaya?—A. Yes; that is the first, and that already is an outlet.

Q. Well, you might have an outlet at Bayou Plaquemine?—A. Yes.

Q. And another at Lafourche?—A. Yes.

Q. And on the east side you could have one at the Manchac, into Maurepas, and then into Pontchartrain?—A. Yes.

Q. And as a matter of fact none of those outlets could afford any relief for the reach of the river from Cairo down to the mouth of the Red River, where they were so afflicted by the flood last spring?—A. I think not.

Q. So it couldn't be a practical question, anyway?—A. I think not.

Q. Even if the river could be diverted to any extent at reasonable cost, into those channels, it wouldn't help this flooded district at all?—A. It certainly could have very little effect, and in my opinion wouldn't have any good effect after a short time.

Q. The greatest effect would be that it might possibly, by creating a more rapid channel, diminish the duration of the flood, but it couldn't diminish the crest; isn't that so?—A. If the outlet remained as large as it was made and the river below it did not deteriorate (which it would), then it might possibly lower the surface of the river in the lower part of the river.

Q. For a few miles up?—A. Yes; for some miles up.

Mr. GALLINGER. I assume that no system of gates could be used so as to control the flood of water through the artificial outlet.

A. It would be very expensive, and very risky in that soil.

Q. In addition to the fact that the so-called outlet system could only relieve a portion of the river afflicted by the floods of 1897, is the other fact that a resort to it might lead to endless complications in regard to the lower river, and it might tend to the creation of new levels and the diverting of the Mississippi entirely, might it not?—A. I think it would undoubtedly have a detrimental effect upon the main river below the outlet. I don't think there is any question about that at all.

Q. The only plan, then, that you regard as at all feasible and reasonable for protection against the floods of the Mississippi River is an extension of the levee system, building better and stronger levees?—A. No, sir. You haven't asked me that question yet.

Q. In what way would you furnish relief against the floods of the Lower Mississippi from Cairo down? Would you do it wholly by the levee system?—A. Not entirely. We must have the levees to hold the water that goes over the bank, and——

Q. Don't you think the levee system ought to be supplemented with some kind of reservoirs along the St. Francis Basin, the Yazoo Basin, or the White River Basin, and perhaps the Tensas Basin in addition?—A. No, sir; I do not. I don't believe in the reservoir system at all. I think there are very few places where it could be applied. You must take into consideration the tremendous volume of water that must be taken care of and also the flood heights. And when you come to examine this table [referring to a blue print] and see the volume of water there is to take care of, I think you will be impressed with that probably a great deal more than you are now.

Q. What would you suggest as the best system of affording relief against floods such as that of 1897?—A. I think one great relief could be effected by the fixing of the banks of the Mississippi River to pre-

vent its wandering around its valley and tearing down its banks and filling up its bed.

Q. You mean the natural banks of the river?—A. Yes; in addition to the levees. For a complete protection against overflow I think, unquestionably, we must have levees; but I believe firmly that if the banks of the Mississippi were fixed, in a very short time the bed of the river would be deepened very considerably, which would have a very considerable effect upon the flood level and lessen the necessary height of levees.

Q. If you should go into an expensive system of enlargement of the levees as a means of protection against the floods, wouldn't it be advisable in a great many instances to make the levee basin wider, to bring the levees farther back and make a bigger basin from levee to levee?—A. I think it would.

Q. Wouldn't that help in a great many instances?—A. It would help to a certain extent, but there are almost insuperable objections to that. You would destroy the arable land, or rather leave it unprotected. I don't know whether you are acquainted with the fact that along the rivers down in that part of the country the immediate bank of the river is considerably higher than the bank as you go back from the river, due to the fact that a deposit was made there as soon as the water overflowed from the main channel of the river.

Q. The sediment first rested there?—A. Yes. Now that is arable land along this river; it is sometimes a strip half a mile wide, sometimes a mile wide, and sometimes wider. But when you go back from the river, especially in the lower part of the valley, you get into the low ground and into the swamps that haven't been cleared, and the people living along these rivers would be almost (you might say wholly) unprotected if you should throw these levees back too far.

Q. But still there might be places where they could be thrown back with advantage.—A. That is true, and the levees ought to be thrown back so far as to give some assurance that they would remain for a number of years. In a great many places the levees are so near the banks of the river and the banks are caving so rapidly that they fall in and the whole levee has to be rebuilt.

Q. Now (coming back to where we were a moment ago) you said that in addition to an adherence to the levee system you would see that the banks of the river were better taken care of?—A. That the banks were fixed so the river wouldn't wander around.

Q. In other words, you would attempt to supplement the levee work by something in the nature of the work you have here on the upper river, by riprapping and by wing dams or dikes?—A. Well, the dikes would come afterwards; they are more for regulating the navigable channels.

Q. You would do it then by riprapping?—A. I would do it by whatever means was the best at a practicable cost. As I was telling you, we are trying a new system on the Missouri River, and I expect great results from it. The system that has been in vogue on the Mississippi has been revetment work, which has gotten up to such a cost——

Q. The revetment work—isn't that a species of riprapping?—A. The revetment that we speak of on the lower Mississippi, the subaqueous part, is a mat of willows extending out sometimes 300 or 400 feet, loaded with stone to hold it down; then, from the low-water line up, the bank is graded and covered with loose stone, riprapping stone; that is the revetment work we speak of down on the lower river. The commission started in, in the first place, to make it very much too light, and the

perience of later years has been to add to the strength and cost of it, til finally, to get a revetment that has any lasting qualities at all, the it has gotten up to $30 per linear foot, which is almost prohibitive long lengths of the river. And it was that fact, and the fact that best revetments are not proven to be fairly permanent, that led me o an investigation of this other method of bank protection which I ve described.

Q. Now this bank protection would indirectly protect the levees from ng undermined; but protecting the natural banks wouldn't give the er bed a larger capacity to contain water, would it?—A. That is ctly what I think it would do.

Q. You think it would?—A. Yes, sir.

Q. It would give it a bigger power of retention in what way?—A. u would lower the bed of the river. If you keep the river flowing one channel all the time, prevent the material from the banks from ng into the river to dam up the channel, you will erode a deeper bed, d, therefore, while you would make your levees secure from being dermined, you would also lower the flood level.

Mr. BERRY. The cost of that kind of work that they have done has en the great difficulty about it, hasn't it, Colonel?

A. That has been, but I am trying to get the commission to go into is new idea.

Q. You think this new idea will greatly reduce the cost?—A. I think will. Here is quite an instructive diagram [referring to a blue-print]. at is a section of the bed of the river made up from a great many oss sections. That is an average section of the river between the rkansas River and Vicksburg. This is the top of the natural bank. his is the average bed that is made up from a great many sections. ow, then, the extreme flood water that we have calculated may come, taken between levees in the average position that they have been ilt on the river, would come up to this line—that is, about 12 feet ove the average bank. Now, then, if that water, instead of going er here, was all kept in here, it would go that high [indicating]—that , about 4 feet higher. Here is the average amount of earthy material at has been taken in from the banks every year. For every mile of ver between Cairo and Donaldsonville, our surveys show that there as been an average every year of 9½ acres of ground 66 feet deep taken t of the banks and put into the bed of the river. When you come to igest that fact you will see one reason why the river can't pass its ater out without overflowing its banks. Now, if it pulls all that aterial down in here, the flow of the water is impeded by just that uch material, which has to be carried along and prevents bottom our; and not only that, but it keeps on caving back here and finally wn goes the levee.

(The blue-print referred to was marked Exhibit L, and follows here.)

Q. Has the bed of the river raised within recent years, in your opin- , from Cairo down, or has it lowered?—A. That is quite an open estion. I will have to answer that by saying I don't know; that the estigations of the commission have not definitely decided that one y or the other. Some of the observations would seem to indicate at the bed in certain parts has raised, and others would seem to show at it has lowered. But these investigations haven't yet been carried t in a manner that will definitely determine the fact, exactly, and at is——

Q. You know, Colonel, some people have the opinion that the increase the height of the floods is from an increase in the height of the bed

of the river. That is a popular notion. What is your view on that subject?—A. I don't think we need to call any such view as that into the question at all to account for the fact that the flood levels have increased in height; there is no necessity of lugging that in. We know that the levees increase the height of the river. We figure on that. We know it positively. If you make the water flow in a narrower place, of course the top of that water will be higher, the surface will rise, unless the bottom is lowered or the velocity increased.

Q. But the question is, will the building of those levees and all that tend to raise the bed of the stream?—A. I don't think it will. On the contrary, I believe that if fresh material were not brought into the bed from the caving banks, the levees would assist in deepening the bed by scour.

Q. Well, that is what some contend, you know.—A. I know it.

Q. Your idea, then, of improving the natural banks of the river, fortifying them, is with a view of deepening the natural bed of the stream?—A. Yes, sir.

Q. And giving it a greater capacity for retaining water?—A. When you protect the banks, you stop the pulling down from the banks of all that material that is pulled down now, and which the river has to carry along with it. If that material is not pulled down into the bed, the river has just that much more room to flow in. In my opinion the protection of the banks of the river is the first thing to be done on the Mississippi River, and the greatest and most important work for its improvement.

Examined by Mr. GALLINGER:

Q. I would ask you, Colonel, whether or not it is a fact that a portion of this soil which is carried down from the banks, as represented by you, is deposited in the shape of islands, or, perhaps, on the other side of the river in the shape of bars of land.—A. Oh, yes.

Q. So that it is not all scattered in the bed of the river to the detriment of navigation?—A. Not just at the point where the material falls in, but it is in the river and has got to be carried along. It may be carried along by the river and deposited farther down on the other side——

Q. Or made into an island?—A. But you see the river has got to carry that along, every foot of it.

By Mr. NELSON:

Q. Your theory is correct, that increasing the capacity of the river will undoubtedly relieve the levees; but the question in my mind (and that, of course, is not settled) is whether your mode of doing it will accomplish it.—A. That is the only point.

Q. Will you please state what has been done in the way of dredging on the Mississippi River and in the way of securing implements for dredging, and what, in your opinion, is the result of such efforts and such expenditure? Give us full information on the subject.—A. Some two or three years ago, perhaps four years ago, just before I had become a member of the Mississippi River Commission, the commission, having suspended work in the river, looking toward the improvement of channels by construction work which was carried on in Lake Providence and Plum Point reaches, considered that it was important to do something in the way of alleviating the troubles incident to bad channels in low water, and went into some investigation as to what temporary means might be resorted to, and concluded to make an experiment in the way of dredging with large machines that could move a great deal of mate-

rial. A dredge boat was built (the first of those that the commission now have) as an experiment—an hydraulic dredge.

Q. At about what cost?—A. I think the original cost of that first dredge was something under $100,000. I don't remember just the figure. And before any definite results had been obtained from this boat (although it promised pretty fairly in the work it was capable of doing) the commission started in to build others. The idea at that time was to build very powerful dredges that could move a very great amount of material in a very short time, and the result of that was to build a very much larger dredge than the first, which has now been found to be too large for the purpose—draws too much water and is unwieldy.

Q. What has been the cost of this other dredge?—A. That dredge cost considerably over $200,000.

Q. And that is too large for any practical use?—A. That has been found to be too large and too unwieldy. Then some private citizens conceived the idea of entering into a contract with the Government to dredge the channels and keep certain depths.

Q. In the Mississippi River?—A. In the Mississippi River, for a certain large sum of money, and they endeavored to get the contract through Congress. And after a good deal of investigation on the subject the commission committee on dredges at that time presented certain figures with regard to the cost of machines and cost of work, and showed to Congress that that particular kind of work could be done by a plant owned and operated by the Government for much less money than the amount for which the private parties proposed to do it. Then in the river and harbor bill of 1896, appropriating money for the Lower Mississippi River, a proviso was introduced which made it compulsory upon the commission to provide a large dredging plant and dredging boats upon an estimate that was made by this committee on dredges. The idea was to have enough very powerful hydraulic dredges to maintain a channel 9 feet deep throughout the year.

Q. At what points?—A. It was to be from Cairo down. The principal part of the work would be between Cairo and Vicksburg. Well, the commission has been building these large dredges. There are now four of them completed and two others under way, and the expectation is to build another during the coming year.

Q. That would make how many?—A. Seven altogether. There are now four completed.

Q. Including the oldest one and the one that was too big?—A. Yes. There were two others added to those two, at a cost of something over an average of $100,000 apiece.

Q. Is there any necessity for this dredging?—A. Well, there is a necessity for getting deeper channels in low water. There are a number of bad places in the river; the number varies from year to year, but it might be said that there are perhaps thirty or more between Cairo and Vickburg where the water gets too low in the dry season to give good navigable depths. The idea was that these dredges could be placed at work before the water had gotten down to low water and dredge out these bad bars and make these channels, the expectation being to make 9 feet of water. These dredges have proved that channels can be made through these bars. They can be dredged out. But the great difficulty is that they fill up again.

Q. Fill up right away?—A. Not right away necessarily. Sometimes a channel may stay open for quite a while; at other times it does not. The river shifts about, and, according to my understanding of the work this year (I am not fully posted, because we have not all the reports),

is that there has been a great deal of trouble even where the dredges have worked; and it is, in my opinion, a repetition of the work that was done on the upper river about thirty years ago, when we had what we called scrapers. We would scrape a channel through a bar by these scrapers attached to the bow of a steamer. We could make the channels—did make them—but as soon as there was a little rise in the river they would fill right up again and the work had to be all done over again. And that, it appears to me, is going to be the result of this work that has been carried forward now.

Q. So this dredge work is not of a permanent character?—A. No; it is not of a permanent character. It was not expected to be of a permanent character, but it was hoped by some of the members of the commission (I can not say that I was ever sanguine about it) that it would be possible to maintain these channels by dredging them and repeating the dredging.

Q. What has been the result of the experiments so far?—A. The results of the experiment so far have not been highly successful in all ways. They have been able to make channels. They have made channels, and in some cases these channels have remained navigable for some time, and in other cases they have not. I suppose they haven't yet got the system in good working order; there is a good deal of experience still required——

Q. Do you regard the method of keeping a channel open by dredging as a judicious expenditure of money?—A. I do not at all. I think it is not judicious at all to rely wholly upon dredging, and I think it was rather forced upon the Government by the clamor of these outside parties who wanted these dredging contracts.

Examined by Mr. GALLINGER:

Q. How much, approximately, have the dredges already built cost?—A. You might say they have averaged over $100,000 apiece.

Q. And there are six of them?—A. There are four completed, two under way, and the seventh is provided for, but not yet built.

Q. It will approximate nearly $1,000,000, won't it?—A. Yes; I think so.

Q. And in view of your opinion, so unqualifiedly stated, that this is not a wise expenditure of money, should that additional dredge be built, do you think?—A. I think that this dredging plant could probably be utilized in connection with other works, as auxiliary; for instance, where a channel is desired and might be obtained in the course of time by proper dike work, the dredges might hasten it by starting the channels in the right direction.

Q. Supplementing it by dike work?—A. Yes; I think that is what we have got to do, to put in some dike work that will not only make a channel but will maintain it. The dredges will cut out the channel, but it is subject to be destroyed almost any time.

Q. In addition to the cost of the dredges can you state approximately how much in money has been expended in the work of dredging?—A. I could not. I should have to refer you for that to Major Handbury, who could give you very full information as to that. A great deal more money has been spent upon other parts of the plant that are necessary to go with the dredges; for instance, the towboats and the pile sinkers, and the various paraphernalia for keeping parties in the field making surveys of these bars and for doing the work. I am not sure, but it seems to me the cost is larger in the way of repairs than it was expected to be, and in maintaining the plant, keeping it at work, and keeping it going. I think it will be found that the cost of the work will be in excess of what has been heretofore supposed, and

ıt the benefit derived will not be commensurate with the cost. I ı't know whether you are entirely familiar with the fact that the nmission two years ago changed the policy with regard to the proving of the river, and the commission was not unanimous by any ans on that subject.

Examined by Mr. NELSON:

Q. I am not familiar with that, Colonel. Please state what the facts .—A. The commission now, according to their resolution, are com-ted to the improvement of the river by means of building levees and dging channels, with some little bank protection at certain points, where there is a threatened cut-off at a neck or in front of a town; y have given up the idea of permanent improvement of the river side of those features. That, it seems to me, is not what the com-ssion was formed for. The improvement of the river, as it seems to , ought to be carried on for a permanent work; and most of the work ıt is being done now, with the exception of the levee building, which s more or less permanence, is simply temporary work which will have be repeated every year, and in twenty years from now you will find river in exactly the same condition it is in now; there will be no vance whatever.

Q. You say the commission is divided on this question, or has been?—Yes. They are not all committed to that policy, but that is the icy of the commission as adopted by the majority.

Q. Of whom is the Mississippi River Commission composed?—A. e Mississippi River Commission is composed of three officers of gineers (Colonel Gillespie, president, Major Handbury, and myself the engineer members), one officer of the Coast Survey, Mr. H. L. rindin; then there are two civilian engineers (Major Harrod, of New leans, and Colonel Flad, of St. Louis); then there is a seventh mem-, who is not necessarily an engineer (and in this case is a member the legal profession), Judge Taylor, of Indiana.

Q. Would you feel at liberty to state how the members of the com-ssion divided on that question? I don't mean for you to give the nes, but did they divide on civil and military lines?—A. I would her you would take that from the reports. It is published in the ceedings of the commission.

Q. What does the report state? Please quote it.—A. The proceed-s of the commission would show.

Q. Are all their votes and proceedings published?—A. They are blished, but how far they are distributed I don't know. The Secre-y of War and the Chief of Engineers are furnished with them.

Mr. NELSON. Can you state, Major Handbury, how they divided on question of improvement?

The WITNESS. The proceedings of the commission, 1896, I think, ws that. I wrote a minority report that year, and I believe some of other members substantially agreed with me in my views, but the nority report wasn't written until after the majority report, and that l already been signed by all except myself, as it did not expressly nmit the commission to the abandonment of permanent improve-nt. The point I was making was simply this: that the work of the nmission as it was being carried on——

Q. By dredging, especially?—A. By dredging with these big dredges l doing no other work within the banks of the river whatever would ve the river in twenty years or a hundred years from now in just the ne condition as it is in now.

Q. Do you mean to say that that is all the work they have been

actually doing toward improvement of the navigation of the river these last few years—simply dredging (outside of the levee building)?—A. And this protection of certain points. The commission started first with the idea of improving some reaches of the river, and they started in at Lake Providence reach and Plum Point reach, which are very bad places in the river. They did a good deal of work there in channel contraction, dike work, besides revetting the banks. Mr. Eads was a member of the commission at one time, you will perhaps remember (afterwards resigned), and he made a strong statement in regard to the protection of banks—that if there were a certain amount of dike works built and the river brought down to certain dimensions there would be no need of bank protection. Well, for some years Congress forbade the protection of the banks—stopped it by Congressional act—a restriction that was afterwards removed. The consequence was that a good deal of that work, especially in the Lake Providence reach, was completely thrown away, because the stopping of the protection of the banks reversed some of the bends, the banks kept caving and caving away, and the contractions then were in the wrong places, and where the channel ought to be there were the dikes. The consequence was that all of the channel work was stopped for a number of years. The commission finally came to the conclusion (which I think every member of the commission holds now) that any work placed in the river ought to commence at some starting point above, which the river could not change. For instance, just above Cairo there is a point where there is rock on both sides; the river is held right in place. If you commence there and carry your work continuously down, whatever work you put into the river you can make count.

Q. Make it of a permanent character?—A. Yes, make it of a permanent character.

Q. And make it do what is necessary?—A. As I say, all of this work has been thrown up; the commission is not doing it.

Q. They are doing nothing of the kind?—A. Nothing of the kind, except at a few points; and all they are doing toward the improvement of the navigation of the river is this dredging with these large, expensive dredges.

Q. And that is of a temporary, fluctuating character?—A. Yes.

Q. Where it is dredged out one year it is likely to be filled up the next year?—A. Bound to. They expect that.

Q. And that is all that has been done?—A. That is all that has been done.

Q. From your testimony I take it your opinion is that they ought to abandon dredging and in lieu of that adopt this other work of fortifying the natural banks of the river?—A. I think that the holding of the banks of the river is the principal work to be done in the improvement of the Mississippi River, and that by holding those banks, keeping the channel in one place, a great deal of the difficulty of navigation will disappear. A great many of these bars, these bad places, have formed in the river from the material taken out of the banks. When you consider that amount of material I gave you (averaging 9½ acres of ground 66 feet deep for every mile of river) that falls in every year, you can see what an immense amount of material the river has got to move along, and how much of the energy of the flowing water is taken up in removing that material, which might otherwise be devoted to cutting the channel deeper.

Q. Here we have expended over $1,000,000 in a dredging plant and the adjuncts connected with it, and nothing of a permanent character

has been accomplished by it.—A. Nothing permanent; no. I don't want to be understood as antagonizing the dredges altogether. I think some of that work is judicious and useful, and that dredges might be used in connection with other work as auxiliary.

Q. But you would do this other work—fortify the banks at the points?—A. Fortify the banks——

Q. And build dikes where necessary?—A. As soon as you get the banks fortified so the river is not subject to change by the caving of the banks, then build the dikes; let them follow the holding of the banks, and in that way you would gradually get a permanent improvement of the river and you would hold the banks so that the levees you built would be permanent structures.

Q. It would fortify the levees, wouldn't it?—A. Certainly; it would hold your banks and the levees would not be falling in.

Q. Would that be substantially applying the principle of the work that you are adopting on the Missouri River, to some extent, to the lower river?—A. Well, I wouldn't go so far as to say that it would take that particular kind of work, but something should be done to accomplish that object—to hold the banks of the river. That, it seems to me, is the main feature in the improvement of the Mississippi River, and until that is done all other work must necessarily be temporary.

Q. In the very nature of the case the building of levees for controlling the river at high water does not help navigation when the river is within its natural banks.—A. They have no effect in low water, of course.

Q. And when the river is below the natural banks of the river it has its own sweet will to tear the bank down on one side and build up on the other, and your idea is to fortify one side by these revetments, or whatever you may call them, and the other side by dikes?—A. To protect the banks where they need protection; to hold them.

Q. And put the river in shape to scour itself out?—A. Yes; that, it seems to me, is a large part of the problem in the improvement of the Mississippi River.

Examined by Mr. GALLINGER:

Q. Could you venture a suggestion of the probable cost of carrying out your views?—A. I could not. As I was saying in regard to the revetment that has been used on the Mississippi River, it has gotten to cost $30 per linear foot. The bank that needs protection, from Cairo down to Vicksburg, is somewhere from 300 to 400 miles, and at $30 a foot that would make a tremendous sum. Now, the question that arises is, Can we reduce that cost by some other form of bank protection? That is the problem we are trying to solve, and it is a problem that I think the Mississippi River Commission ought to give more attention to than it has.

Q. Isn't it safe to say that to carry out the comprehensive project of improving the river according to the views you have expressed, Congress may as well face the fact that an appropriation of $100,000,000 or more would be necessary?—A. I think not. As I say, it depends upon what the outcome of our experimental work is. If that experimental work is successful I don't think it would take half of that.

Q. But if not successful it would cost fully that?—A. No, sir; I wouldn't put it that way. I would say if that is not successful, let us work up something else; let us go to digging at this thing until we find something that is successful within reasonable cost.

Mr. BERRY. But to follow out the old plan it would reach the sum suggested, would it not?

The WITNESS. According to the old plan I think the estimate was about $66,000,000 for the old revetment plan.

By Mr. NELSON:

Q. Aside from the levee system, the only plan you have, as I understand, at present, for improving the navigation of the river is simply this dredging?—A. Yes, sir; that is the plan now being carried out.

Q. That is the only plan in vogue at present?—A. Yes.

Examined by Mr. GALLINGER:

Q. And concerning this matter of dredging, Colonel, it seems the boats built and the one to be built, will aggregate a cost of in the vicinity of $1,000,000. Now, what about the matters auxiliary to those boats to which you have called attention. Have they cost several hundred thousand dollars?—A. I couldn't say offhand what they have cost. I would suggest that Major Handbury can give you very much closer figures on all of those items than I can, because he has them, I think, right at hand.

Q. Is it left optional with the commission to adopt any method for the improvement of the river? For instance, an appropriation is made; can you use a portion of that at your discretion, for dredging or any other purpose you see fit; is that the situation?—A. It is hardly optional, because the provision in the last river and harbor bill seemed to contemplate that the commission should provide this large dredging plant, the phraseology of the provision in the river and harbor bill of June, 1896, seemed to indicate (at least that was the impression of the members of the commission) that it was compulsory—that it was mandatory that we must provide this dredging plant to——

Q. So that matter of dredging, then, was the creation of Congress rather than of the Mississippi River Commission?—A. Well, the Mississippi River Commission had started in on an inquiry, you know; they had started in on experimental work in that direction, but this combination of citizens that went to work to get the contract from Congress spurred up—I don't know whether you would say it spurred up Congress, but it created a sentiment, you know, that it was possible to accomplish all of this desirable result of obtaining low-water navigation with a good, deep, wide channel by putting in these dredges; and it was shown by some of the members of the commission who were called before the Congressional committee (I didn't have the honor to be called) that these dredges could be built and operated by the Government to attain the result that was desired at a less cost than this company expected to get the contract for. I think it is very likely that the Government could do it. If either party could do it the Government could do it just as well and perhaps more cheaply than these other parties, because the other parties, of course, had their profits in view, and probably they expected to make pretty good profits.

Maj. THOMAS H. HANDBURY, having been sworn, testified as follows:

Examined by Mr. NELSON:

Q. Major, do you have charge, under the War Department, of the reach of the Mississippi River extending from the mouth of the Missouri to Cairo?—A. I do.

Q. How long have you been in charge of that part of the river?—A. Since the 14th of January, 1896.

Q. You are also a member of the Mississippi River Commission?—A. I am a member of the Mississippi River Commission, whose jurisdiction extends from Cairo to the Head of the Passes.

Q. Are you a member of the Missouri River Commission, also?—A. I am a member of the Missouri River Commission, whose jurisdiction extends from the mouth of the Missouri to Sioux City.

Q. You were present this morning and heard the testimony given by Colonel Stickney touching the Missouri River?—A. Yes, sir.

Q. Do you concur in the main details of that testimony, or is there any point on which you differ with him?—A. I concur in about all he said, although I am not quite so enthusiastic as he is about the matter of his new plan for preventing erosion of river banks. It is a matter of experiment and we can not tell yet how it is going to result.

Q. That is a plan of riprapping?—A. No; it is called the bank-head plan.

Q. I should call it a system of riprapping very strongly at intervals.—A. That is about what it is, but I believe he calls it bank-head revetment. His theory about that, as he explained to you, is that by holding certain points in a bend (say at the upper part) and then holding points further down the river will only erode back a short distance between the points so held, and that it will be cheaper to put in these bank-heads to hold these different points than to make a continuous revetment along the bend. That is the theory he is going on. He has put in some work of this kind on the Missouri River, as he explained to you, which appears to give favorable results, although it is not altogether satisfactory to all the other members of the commission. It was an experiment. We are looking around for some cheaper way to do this work, and are willing to try almost anything that comes along that offers any prospect of lessening the expense of making revetment.

Q. The former system has been a very expensive one?—A. The former system has been a very expensive one. The Missouri River Commission at its last meeting concurred in Colonel Stickney's plans for improvement at certain points, making use of these bank-head revetments so as to give them a more extended trial. Until his system had that trial and we get some results from it, we are not prepared to say whether we can adopt it definitely or not. This is the system he wishes to get the Mississippi River Commission to adopt.

Q. I don't think we will occupy any more time on the Missouri, unless there is something you would like to supplement in connection with Colonel Stickney's testimony on that.—A. I don't know that there is anything I could say that would give you any more information than he has given you. I fully concur with him in most of his remarks, especially about the manner in which appropriations are made. Of course you have had your attention called to the different phases of that.

Q. That is, you think it is very unwise to put clauses in an appropriation bill providing that certain amounts shall be or may be devoted to certain specific points. You think it would be better for the commission and that they could do better work if the appropriation was a gross sum without any legislative direction as to points?—A. Yes; it would be much better. And if there are points that in their judgment are of sufficient importance to require special work, special appropriations should be made for them.

Q. Are there any so-called harbor improvements in the river below Kansas City? By harbor improvements I mean these improvements in front of towns and to protect railroad bridges, etc.—A. Yes; there are several below Kansas City.

Q. Where you have been making improvements?—A. Yes, sir. The aggregate of the allotments made for the several plans along the river in the last river and harbor bill was greater than the amount appropriated.

Q. To different points on the river?—A. To different points on the river. At our last meeting, I think it was, or the meeting before the last—the meeting at which we allotted the appropriation made for the Missouri—Colonel Stickney laid before the commission his project for the expenditure of the money available. It contemplated putting in these bank head revetments at a number of places mentioned, thus doing a little necessary work at each place. He hoped in this way to satisfy these localities, although they could not be given the full amount mentioned in the bill.

Q. If they had given the full amount, it would have exhausted the appropriation?—A. Yes. The full amount would not cover the estimated cost of the work to be done.

Q. What is the distance, in round figures, from the mouth of the Missouri to Cairo?—A. It is about 200 miles.

Q. Do you divide that into reaches, as they do above?—A. No; the original plan that we have been working on for a number of years contemplates the improvement of the river by concentrating the water into a definite channel by means of what we call hurdles (they are popularly called fences), which check the velocity of the current and cause a deposit about them; that deposit gradually increases, and after a while willows begin to grow. This growth of deposit continues until it gets up to high water. It is contemplated to then revet the bank, and in that way keep the river in shape. When we once get it into shape we expect, by the expenditure of a small amount every year, to keep it in that condition.

Q. That is the character of your improvements on this whole reach of the river?—A. Yes; from here down to Cairo.

Q. By building so-called hurdles?—A. By building hurdles; yes.

Q. What are they composed of?—A. They are composed of piles or clumps of piles driven from the shore out to the channel line. For instance [referring to a blue print] here is St. Louis. This is on the farther side of the river. Now, we build hurdles out like this; the project is at intervals of a thousand feet, but we build only every other one, and then if we find it necessary to build the intermediate ones we do so. These hurdles are generally built at high water. The Missouri River brings down a large amount of sediment, and puts it into the river here, that has to be disposed of in building up these banks here, or carried down through——

Q. But it gathers in there among your hurdles?—A. Yes. Now, this at one time was scattered all around here, opposite Jefferson Barracks, at what is called Horse Tail. That was a very bad place in the river, and was practically the head of navigation in low water. Before these improvements were commenced between 2 and 3 feet of water only was found here at low stages. The water scattered around and wasn't concentrated. Now we have 6 or 7 feet down there at low water.

Q. And that is the character of the work you are carrying on down to Cairo?—A. That is the character of the work we are carrying on down toward Cairo; we are not at Cairo yet, though, only part way down. This part is pretty well improved [pointing]; the contraction works having been in five or six years, the sand bars have settled themselves over to one side of the river, and the channel comes over on the bluff side. This kind of improvement is perfectly practicable from here down to Cairo, but when you get below Cairo you get an entirely different state of affairs. We try here to get the river on the bluff side always, so we only have to revet the other side. Sometimes there are places where we can not get the river over against the bluff.

Q. So long as you have carried on this work of contracting the channel by means of hurdles, has it proved a success?—A. Oh, my; yes. Here we have all this reach of the river (that we have done more or less work on) clear to Grand Tower, about a hundred miles down. We have greatly improved the navigation at low water. The present is an extreme low-water season. It is now down a foot lower than our zero, which is ordinary low water. I have soundings taken by the boats in my charge as they cross the shoal places. The reports come in every day. Here is the report of a boat that came in to-day. All these places that are named here were bad crossings. There is quite a number of them that have been entirely eliminated by this improvement. For instance, at Arsenal Island we have 6 or 7 feet. Carrolls Island used to be a very bad place, but has been improved. Twin Hollows—that was a 3-foot place generally at low water, but they have good water there now. This is the result of the improvement that has been going on. The appropriations are not large enough to enable us to do all we would like to.

Q. You have commenced this work, then, at the mouth of the Missouri and are carrying it downstream?—A. Carrying it down—yes.

Q. How far down have you got from the mouth?—A. We are not attempting to complete, or anywhere near complete, it as we go down. We do such work as will give immediate benefit to navigation; then we expect to go back over this and make it more permanent. We have done some work down as far as Commerce, about 25 miles above Cairo. This was a very bad locality—Powers Island (the steamboat people call it the Goose Island) country. A great deal of the water went down the slough behind this island. A hurdle dam was built across this, which checked the water gradually and caused it to fill up with deposit. Now there is only a little stream that you can step across, where last year at this time half the river went down. This is all shoal water, and this is all built up. The consequence is that the water goes down here to the benefit of this space down here.

Q. So it scours the channel?—A. It scours a good channel.

Q. And you have carried on this work to a greater or less extent almost down to Cairo?—A. Almost down—yes; but as long as there are one or two places that we have not improved to 5 or 6 feet, these limit the draft of the boats going down.

Q. Now, you say the plan is to have the sand fill up among the hurdles, and by and by form a new bank with willows growing on it, etc.?—A. Yes.

Q. And in time make it as high as the river in high water?—A. Yes.

Q. And then supplement it eventually by revetment?—A. By revetment; yes.

Q. Now, have you attained that result at any part of this work?—A. Oh, yes.

Q. So you have demonstrated that it can be accomplished?—A. Yes.

Q. To the extent that you contemplate?—A. If you gentlemen could only take a day or half a day and go down even as far as Arsenal Island, I could show you where away back (not as far as you could see, but away back) trees are growing on this bank [pointing], and right in front of it there is a great willow growth and houses are being built on that place there. In 1895 we had an estimate made of the amount of accretion that had taken place down as far as we had gone then——

Q. From St. Louis to where?—A. I think it was down to Ste. Genevieve. Here is the accretion in acres [pointing].

Q. That has resulted from your hurdle or contraction work?—A. Yes. That amounts to 7,416 acres.

Q. From the mouth of the Missouri down to Ste. Genevieve?—A. Yes. A great deal has been built up since this statement was made. This bank comes clear over here and down here.

Q. Well, have you revetted any of these banks that you have thus created?—A. Yes; there are a good many revetted along here. But we have to watch them. Just at the present time I am doing a good deal of work repairing them.

Q. Do the willows grow on them?—A. Yes; when they get up to about high water. It is a matter of official record, derived from a series of sediment and discharge observations taken in 1879 at St. Charles, on the Missouri River, that the amount of material brought down in suspension by that river, together with the sand rolled along the bottom, was sufficient during that year to have covered a space 1 mile square to a depth of 470 feet, or, in other words, sufficient to fill a space 2,500 feet wide and 105 miles long to a depth of 8 feet; or would fill a street 100 feet wide, 53 miles long, to a height of nearly 400 feet. You see that is put into the river, and we have to take care of it. It has to go through here or it will be piled up on the sides somewhere. We pick up a large portion of it and form these new banks. The narrowing of the river here has resulted, as I find from observations that I have had made recently, in lowering of the bottom of the river.

Q. Deepening of the channel?—A. Deepening of the bottom of the river. The other day I had some discharge observations taken, from which it appears that at the same stage on the gauge the amount of water going down was more than it was when previous observations were taken, showing pretty conclusively that in the rectification of the river the bottom is dropping down. The river, ordinarily, you know, is made up of deep pools and wide shoals. As we contract these wide places and get rid of the shoals, it gives it a more uniform slope all the way down.

Q. It has a tendency to give the bed a gradual and continuous slope instead of having it in pools and bars?—A. Yes.

Q. As it would be ordinarily?—A. Yes.

Q. Now, as I understand it, this form of work that you have described here is substantially the character of the work all along your reach of the river?—A. Yes; the object to be accomplished on the stretch of the river from the mouth of the Missouri to St. Louis was to gain 6 feet of water, and from St. Louis to Cairo 8 feet.

Q. At low water?—A. At low water; yes.

Q. Will you please describe a hurdle, so called.—A. A hurdle, as the term is here used, is one of many silt-arresting devices that have been experimented upon in this country and elsewhere. The hurdle consists, essentially, of a row or of parallel rows of piling, the piles driven either singly or in clumps, the piling being connected lengthwise of the hurdle by wattling of fine brush or by curtains composed of brush and lodged against the upstream side of one of the rows of piles, the whole forming a permeable dike through which the silt-laden current can pass, though with greatly diminished velocity, resulting in deposits of silt above and below the hurdles.

These deposits are generally soon overgrown with willows or cottonwood, and after they arrive at sufficient height they can be revetted on their river fronts. To guard against loss by scour of the piles, a broad flexible mattress is first sunk on the line of the hurdle. Through this mat the piles and clumps of piles are driven. During the past year the hurdles have been constructed of clumps of piles, three piles and upward to each clump. These piles are driven so that when their

ıpper ends are drawn together by means of a wire rope they form a ort of pyramidal structure, the horizontal distances of the piles from ach other at the surface of the river bed being 8 to 10 feet, depending nainly upon the depth of the water.

The wire ropes are made on the work; they are composed of 14 to 18 trands of No. 14 galvanized iron wire. They are drawn taut by means f the pile-driver machinery. At each turn of the rope around the ıpper end of the clump of piles a spike is driven as an additional guard ıgainst the rope slipping, though the wire itself generally binds or cuts nto the piling sufficiently to prevent any slip. This method of drawing he upper ends of the piles together appears to be better than the old me of bolting them.

The tops of the piles are generally at an elevation of 20 feet above xtreme low water, excepting that in the curtain or wattling row the op of one pile of the clump is at an elevation of about 25 feet above hat stage in order to intercept a drift at high stages and prevent it rom crossing the line of hurdle and dragging the top of the latter with it.

The curtain or wattled row is braced by vertical diagonal braces heeled against a row of clumps spaced at such distances below as to nake the angle of the braces about 45°.

The heel of the brace is held by a clevis passing around one of the iles of the lower clump, with its pin through the brace. At top the race is bolted to one or more of the piles in the upper clump.

The piling of the hurdle row is so spaced as to represent an equivaent of one pile to the linear foot of hurdle. The piles are driven by neans of the hydraulic jet as well as by the hammer, the latter weighing ,400 pounds, and sometimes by both combined.

The completed curtain, or the wattling, whichever may be used, is enerally carried finally to a height of 20 feet above extreme low water. he mattress is from 60 to 135 feet in width, depending upon the depth f water and consequent length of piles, as well as upon liability of the ed to suffer from scour. It is fabricated upon floating ways, in place, y wattling brush upon poles spaced about 5 feet apart and in any ength desired. Continuity is obtained by lapping the poles and fastenng them together with spikes and wire. When additional strength is equired wire cables are used across and in the direction of the length f the mattress. The brush is spiked to the poles at the edges of the nattress and at other points, about one spike to every third pole. In inking the mat a little less than 1 cubic yard of broken rock is required o a cord of brush.

The piles used in the hurdles run in lengths from 25 to 60 feet, and heir average penetration in the bottom is about 15 feet. They are lriven with the large end down.

At the shore end of the hurdle the bank is revetted for about 300 eet, of which 200 feet is below the axis of the hurdle.

In constructing the shore revetment a mat about 120 feet or more in vidth, its inner edge at the surface of standard low water, is sunk. he bank is then eventually graded to a slope of one-half and covered vith riprap. Where necessary to grade the bank by artificial means the rading is done by the hydraulic method or by means of shovels, etc.

Q. Have you any levee work along your reach of the river?—A. No evee work comes in my district at all.

Q. Your whole work is confined to this class of work you have been lescribing?—A. To contraction work and revetting banks; yes.

Q. What appropriation was made in the last river and harbor bill or your reach of the river?—A. Two hundred and seventy-five thou-

sand dollars by the last river and harbor act, $673,333.33 by the last sundry civil act, and $325,000 by the general deficiency act.

Q. Was it in a lump sum or was it divided up?—A. The appropriation is for the Mississippi River between Minneapolis and the mouth of the Ohio, and of this amount so much shall be expended between the mouth of the Ohio and the mouth of the Missouri.

Q. It is left in such a condition, then, that you can expend it wherever you like?—A. Wherever we can do the most good for the interests of navigation. Occasionally there is a clause which provides that a certain proportion of it may be expended at a certain place, in the discretion of the Secretary of War, and then again there are mandatory clauses.

Q. I would call your attention, Major, to the appropriation made in the last river and harbor bill for the prevention of the flow of the Mississippi River into the Ohio through Cache Creek, and ask you to inform the committee as to whether there is any danger of the Mississippi River breaking over its banks into Cache Creek and from thence into the Ohio?—A. I don't think there is any immediate danger, or any danger in any reasonably future time, of the Mississippi getting over into the Ohio River through the valley of the Cache Creek. When the Mississippi gets high, at anything like a bank-full stage, it backs up the Ohio and up through Cache Creek and makes the water going through the Ohio and the water in the Mississippi at Beech Ridge almost on the same level.

Q. The bottom of Cache Creek is much higher than the——A. The bottom of Cache Creek, at a point near Beech Ridge, is something like 9 feet above the surface of the water in the Mississippi River at low water, and at the outlet of Cache Creek into the Ohio it is 12 feet lower than the Mississippi River at Beech Ridge. There is quite a fall in Cache Creek when the Ohio is low.

Q. In your opinion, then, there is no immediate danger of the Mississippi flowing over its banks and going over the railroad and into Cache Creek?—A. No; I don't think there is any immediate danger of anything of that kind happening. The high water of the Ohio frequently comes through the Cache River and empties into the Mississippi River.

Q. Is there any danger of the Ohio breaking in through that curve and going into the Mississippi up there?—A. No; I don't think there is any immediate danger of that.

Q. Is there any danger of the water from one river forming a permanent channel into the other river so as to make that space below Cache River an island?—A. I don't think there is any danger of that. The distance from Beech Ridge down to the junction of the Mississippi and the Ohio is about 11 or 12 miles at low water, and the distance from Beech Ridge, by way of the Cache River and the Ohio, to the same point, is about 14 miles, and the Mississippi River would not be more liable to take the longer course to get down to the present point of junction with the Ohio.

Q. And the Ohio River would hardly flow upstream.—A. No. Although the Ohio River at high water does back through Cache Creek and into the Mississippi near Beech Ridge, with a fall at those times of about 1 foot.

Q. What work have you done on this Cache River improvement?—A. Since the appropriation was made I have revetted the bank for a distance of about a mile in the vicinity of Beech Ridge.

Q. Is that about all the work that is needed there?—A. Well, this

whole bend, in the course of the general improvement of the river and the rectification of the channel, will have to be revetted to hold it there. We want to revet that so as to hold it in some sort of a permanent position, and also to prevent the sand from getting into the river and coming down and forming obstructions and changing the channel down below. The sand that comes down forms a bar, and we don't know where that is going to drive the water to. There is a very bad piece of river from Commerce you might say clear down to Cairo that has to be taken into consideration in the general improvement of the river. I do not think that there is any immediate necessity for doing any special work at Beech Ridge, especially if it is to be done at the expense of other portions of the river that are in more need of improvement in the interests of navigation.

Q. How much of the appropriation have you expended, about?—A. I could not say, because we have not yet figured up the expenses. The work is only just closed for the season.

Examined by Mr. GALLINGER:

Q. What was the amount of the appropriation?—A. $100,000.

Q. And, in your opinion, was that a wise expenditure of public money, all things considered?

Mr. NELSON. I don't suppose you have expended much of that appropriation?

The WITNESS. Oh, yes; we have spent a good deal of it.

Q. Please state whether or not, in your opinion, that appropriation made by Congress was a wise expenditure of public money, all things considered; I mean by that all things considered in connection with the river improvements.—A. I do not think it was necessary for the interests of navigation, and I do not think it was necessary to have expended it at this time.

Q. You are a member of the Mississippi River Commission. Coming now to the river from Cairo down—you heard the testimony of Colonel Stickney as to the stages of the flood at Cairo, Paducah, St. Louis, St. Charles, and Grafton. His statements as to the gauges of water during the flood at those points are correct?—A. Those are matters of record. I believe they are correct as stated by him.

Q. You are familiar with the river from Cairo down?—A. Reasonably so; not so much so as from here down to Cairo.

Q. What, in your opinion, is the best and most feasible method of checking and restraining and governing the floods on the Mississippi below Cairo?—A. I think the most feasible method is by means of levees.

Q. Do you not think that the closing of these river basins that has been going on of recent years (the St. Francis, the White and Arkansas, and the Yazoo basins) has had a tendency to aggravate or intensify the floods in the lower part of the river?—A. They have had a tendency to raise the flood level.

Q. That is what I mean—to raise the water higher and aggravate the flood.—A. Yes.

Q. The chief damage done in the lower river district by the flood last spring was by the river breaking over the levees because they were not high enough?—A. They were either not high enough or not substantial enough.

Q. In most cases because they were not high enough?—A. In most cases. A great many of those levees that were built by the States and the local authorities were not constructed with the care that is exercised now in building levees.

Q. Most of the crevasses occurred in the State levees?—A. There were no Government levees in which there were any crevasses at all. These crevasses were all due inherently to low grades, weak profiles, or old, imperfect, or incomplete construction. None of the levees built by the United States were broken.

Q. This flood of 1897 was primarily caused, in the first instance, and brought to its highest stages by the waters from the Ohio?—A. Yes.

Q. It was intensified and prolonged by the waters coming from the Upper Mississippi and Missouri, wasn't it? I don't mean raised, but it continued the flood a longer period?—A. It continued the flood, and then there was a second flood that came out of the Ohio River that kept it up.

Q. When did the second flood come?—A. About two weeks after the first.

Q. Did it come at such a time as to meet the flood from the Mississippi above Cairo?—A. Well, the flood in the Mississippi above Cairo was not even up to what we call the ordinary stage for that season of the year.

Q. At no point or time?—A. Not from St. Louis down. It was only what we call an ordinary high water.

Q. There was no flood, then, for that season of the year?—A. Nothing that we would call a flood. It was high water, and it was water that we do this hurdle work in generally. Twenty-five feet is a good stage for us to put this hurdle work in, and we were doing some of that work then—just starting on it. The high water of 1897 in the Ohio reached its maximum of 61.5 feet at Cincinnati on the 26th of February. The highest previous record at that place was 71.06; that was February 14, 1884.

Q. How about the Cumberland?—A. The Cumberland at Nashville reached its maximum, 49.25 feet, this season—March 20. The highest previous record was 55.3, on January 22, 1882. The Tennessee River at Chattanooga reached its maximum on March 15 at 37.9, the highest previous record being 54, on March 1, 1875.

Q. From this it would appear, Major, that at neither of these points was the river up to as high a stage as it had been at previous times.—A. No; but these high waters came down and joined, you see.

Q. They all combined at the same time?—A. They all combined at the same time; and at other times the high water in one river had time to pass off before the water from the other rivers came down on top of it.

Q. The controlling feature of this flood, then, was that the high water at these points occurred at the same time?—A. Yes; at nearly the same time.

Q. So as to join there at Cairo?—A. As these flood waters passed into the Mississippi River they resulted in a maximum height of 51.6 at Cairo, March 25, 1897. The crest of the first wave had scarcely passed by when it was followed by another wave, which did not reach quite to this height.

Q. That was from the Ohio?—A. That was from the Ohio. The highest previous record at Cairo was 52.2 feet. So you see it was within six-tenths of a foot of being the highest record that we have had at Cairo.

Q. And the distinguishing feature of the flood was its long continuance?—A. That was it. The water reached the stage of 49 feet on this gauge on March 14 and remained practically at or above that stage until April 17, a period of thirty-four days.

Q. And in the meantime the high water came down from the Mississippi?—A. In the meantime the water came down from the Mississippi and kept that up, although it was not very high water.

Q. No; but coming in connection with the other it helped to prolong it?—A. No previous flood has ever prevailed at this point for anything like so long a time. The Upper Mississippi was not above medium high stage during this time; and, fortunately, the tributaries to the Mississippi below Cairo were not above the medium stages when the flood wave passed them.

Q. The flood was not aggravated by any extraordinary outpouring either of the St. Francis River, the White River, or the Arkansas River?—A. No; they were not above the ordinary high-water stages. The St. Francis River would not cut much of a figure, because its watershed is not very large, and if there is high water pouring out of the mouth of the St. Francis—any large quantity coming from the St. Francis—it usually comes from a break in the levees somewhere along the St. Francis front and is the Mississippi River water getting back into the Mississippi.

Q. Well, the White and Arkansas together are capable of producing quite a flood?—A. Yes; they have quite a drainage area, but this season they were not extraordinarily high. That was a fortunate occurrence, too.

Q. As I understand, of recent years they have been closing up what is called the Yazoo Basin, the White River Basin, and the St. Francis River Basin.—A. Yes, sir.

Q. Can you give the area of those basins, approximately?—A. The St. Francis Basin, the area that will be protected by the levees when completed, is about 3,490 square miles.

Q. Can you give the width or length of it?—A. I can give you the length of it. The total contemplated levee line amounts to about 224 miles, of which 115 miles have been constructed. This work has been done partly by the United States and partly by local levee boards. The State of Missouri has built 26 per cent, the State of Arkansas 40 per cent, and the United States 34 per cent.

Q. Now, the White and Arkansas Basin.—A. The levee line is 64.4 miles long. The territory to be protected is a narrow strip, varying from 6 to 30 miles in width, lying on the right bank of the Mississippi River, and having an area of about 910 square miles.

Q. The Yazoo Basin.—A. The Upper Yazoo district contains about 124 miles of levee. The Upper and Lower Yazoo Basin contains 7,151 square miles—that is, these levees will protect that much from overflow. The Lower Yazoo, the length of its levee line is 186 miles, covering about 215 miles of river. There is about 215 miles of river front on the Lower Yazoo Basin. And then there is the Upper Tensas. The levee lines in the Upper Tensas district are about 173 miles long.

Q. And that has been closed?—A. That has been inclosed; yes.

Q. That covers the basins, doesn't it, up above the Red River?—A. Yes.

Q. Now, let me ask you this: If it were possible to relieve the Mississippi River from the effects of the floods and overflow by means of reservoirs would not the most appropriate places have been at one or all of these basins?—A. Those would have been the proper places to have established reservoirs, but there is a little difference of opinion as to whether the flooding of these basins—take the St. Francis Basin, for instance—as to whether the flooding of the basin, allowing the water to go over into the basin in its upper reaches, diminishes the flood

water down below where it comes into the Mississippi again. It is maintained by some of the engineers, and especially the engineer in charge of that division (Mr. Pharr), that the flood water will not always reach a higher stage at Helena if you close the whole basin than it would if it were left open. That is a little different from the idea Colonel Stickney expressed.

Q. Please state that again.—A. He maintains that the flood level at Helena, where the St. Francis would come in, will not be higher if you close in the whole of the St. Francis front—or at least that during this last flood water the water would not have been so high on the gauge at Helena if you had closed in the front as it was with the front open and the water allowed to come into the basin, because the water that came out of the St. Francis River joined the Mississippi River just about the time the top of the flood of the Mississippi (coming down the main river) got there, and so raised it.

Q. That is, it would pass over the banks of the Mississippi into the St. Francis Basin, then make that circuit in there and get back to Helena as quick as the waters in the Mississippi would; in the nature of the case that can't be so.—A. That is not the idea exactly. The first part of the flood water that comes down gets over the banks there, fills up the St. Francis Basin, and goes through the swamps and down to the Mississippi. That occurs before the crest of the second high water has come down the——

Q. Then he is assuming that the crest of the high water in the Mississippi comes down at the same time as the surplus water from the St. Francis Basin?—A. Yes.

Q. But that is an assumption that is not founded on fact.—A. Well, I don't know. He has some reason for saying that the flood waters will be carried off faster by closing the basin, and get by Helena quicker, and that the water will not be so high if you close the front of the basin.

Q. What is the distance from New Madrid to Helena?—A. It is about 235 miles.

Q. And what is the average breadth of the basin, supposing it wasn't leveed?—A. The average width would be nearly 15 miles.

Q. Now, his theory is that if the water had free room there for 235 miles in length and 15 miles in width there would be as high a stage of water in the river as if that same water was confined within the limits of the levees along the banks?—A. Yes; that it would pass off.

Q. That is, if instead of having a channel 235 miles long and 15 miles wide for the high water to pass over, you confine it to a narrow channel between the levees (not averaging over a mile wide) that that narrow channel wouldn't be any higher than the 30-mile channel. Now, do you believe that that is a correct view to take of it?—A. Well, but you must take into consideration that in this wide channel it is through a swamp, trees, and bushes, and is obstructed there.

Q. I take that into account. But do you believe that if that basin was entirely open the crest of the high water would be as high at Helena as though you had the whole basin confined?—A. That would depend a great deal on circumstances.

Q. Taking the water as it was last spring.—A. Taking this particular spring, you must remember there were two floods, one following after the other.

Q. Well, take either one of them.—A. We must take the two floods into consideration. The first one comes on top of the second. The first flood comes over the banks and proceeds to fill up the basin, and goes on down——

Q. Doesn't the same law govern in either case? Isn't the natural esult of narrowing a channel to raise the elevation of the water in it?—ı. It will raise the elevation of the water or lower the bottom of the hannel.

Q. Now, do you mean to say as an engineer, Major, that the closing ı of the St. Francis River Basin does not tend to raise the elevation or crest, or wave, as you call it) in the Mississippi River?—A. It aises it along the front, for instance—along that front; but when you llow this water to get over and get into the basin it lowers it. Then 'ou get down to a certain point where this water comes into the chanıel again, and there, of course, it is raised.

Q. Yes; below the junction it is raised.—A. That is just what I was speaking of. Helena is below the junction.

Q. Yes; but the water doesn't come in at the same time or in the same degree. You are assuming that it goes at the same rate of speed.—A. No; I am assuming that the crest of the second flood came down to Helena just as the first flood that went over into the St. Francis Basin got to Helena, and that that raised it (as he shows by his figures) a little higher than it would have been if the whole front had been closed, because the first flood would have gone clear on and gotten by Helena before the second flood reached there.

Q. Don't you know that that puts you at issue with the Mississippi River Commission and with Captain Starling? I understand the Mississippi River Commission has decided (a majority of the commission) that it is unsafe to close that St. Francis River Basin until you make the levees higher.—A. I don't know as they are on record exactly in that way.

Q. If that is true (that it is unsafe to close the St. Francis River Basin until you fortify the levees below), manifestly it must be true that the closing of that basin has raised the river, or will raise it, at high stages of water.—A. That basin is only a small feature of the problem. When you take——

Q. That is hedging. You ought to give me a straight answer.—A. I am willing to give a straight answer if I can get at exactly what you are driving at, but I am just mentioning the facts as they are on record.

Q. Will the entire closing of the St. Francis River Basin have a tenlency to lower or raise the crest of the high-water wave in front of that basin from the top to the end of it?—A. It would have a tendency to aise it. But I am speaking about the point below the mouth of the St. Francis, where it goes into the Mississippi.

Q. You claim that it will have a tendency—— —A. It would have a endency to raise the water all along the front; but whether it will aise it or lower it at the point of junction—where the water comes in gain—or not is a question that admits of some doubt.

Q. That would depend on the question of whether the two currents nade the same rate of speed. If there are two currents separated here naking for a point below, if they both travel at the same rate of speed nd make the same junction, and there is no waste of water, why, of ourse they will form the same crest below?—A. Yes.

Q. But suppose one current travels faster than the other, or suppose here is a waste in one and not in the other, then in the nature of the ase they can't form as high a crest as they would if it was all in one hannel; doesn't that look reasonable to you?—A. That is very reasonble. But you must take into consideration that there is a second 'ave, a second crest, following this first one.

Q. Well, that second crest would operate equally on both, wouldn't it?—A. No; the second crest is the one that gets to the mouth of the St. Francis just at the time the water sent over the banks from the first crest gets there.

Q. Well, I am assuming that last spring there had been no levees and you had two crests, as you call it; that is, you had two distinct rushes of water. Now, each of those two stages of flood would manifestly operate alike on these two different currents, wouldn't they?—A. Well, the second crest that comes down the main river goes on top of the first crest that goes around through the basin, and that (as I understand Mr. Pharr's figures) makes it higher at Helena, which is just below the junction. If the whole of the first crest had gone down the main river it would have gotten clear out of the way before the second crest came down in the main river.

Q. If the basin is open, doesn't the second crest come down in the basin, as well as in the river? You are assuming in your statement, Major, that the second crest will come down the river, and not down the basin.—A. It comes down the basin, too. Of course, a portion of it goes down the basin, but that portion lags behind, don't you see?

Q. Why does it lag behind in the one case more than in the other?—A. It doesn't lag behind any more in the one case than in the other.

Q. Well, you are talking about two crests. Now, the first crest takes two channels?—A. Yes.

Examined by Mr. BERRY:

Q. If I understand, Major, if there was no basin there the first crest would have all passed on much more rapidly than that part of it which left the river and went around into the St. Francis Basin?—A. That is the idea.

Q. There coming a second crest, which would combine at the mouth of the St. Francis with the water which had gone around in the basin from the first crest, would make the water higher at the mouth of the St. Francis than if all the water from each flood had gone in the main river; that is the idea, isn't it?—A. Yes, sir.

Q. And the water that would go into the St. Francis Basin from the second crest wouldn't reach the mouth until later on?—A. No. That is Mr. Pharr's argument, as I understand it.

Examined by Mr. NELSON:

Q. Well, do you concur in Mr. Pharr's argument?—A. I can't say that I exactly concur in it.

Q. Well, to sum up, Major, you don't see your way at present to concur in that view of the case?—A. No; I can't say that I do until I get some further data on the subject.

Examined by Mr. BERRY:

Q. You think, though, that it is not improbable or impossible that it may be true?—A. No; I think it possibly may be true; and it is something that will be studied up more by the commission and by the district engineer in charge before they will close up the basin.

Q. But as at present advised your opinion doesn't concur with his?—A. I must say that I beg to reserve my opinion on the subject until I get more data on the subject. I would say that until I had an opportunity of reading these reports and looking somewhat into the matter I was of the same opinion that you (Mr. Nelson) are, that allowing the waters to go over in the basin would make some material difference in the height of the flood waters below. And it might, under

certain circumstances—for instance, if there is only one flood to go down, that body of water that hangs back, as it were, might result in a lowering of the flood water, say, at Helena; but if there is another one on top of it, as there was this spring, it might not.

Q. Yes; and there is the point I don't understand. When you speak of another flood coming on top of the first one, wouldn't the second flood, like the first one, distribute itself into two channels?—A. So it would, but the first flood—I would simply have to go over the same ground again to explain it.

Q. Well, I will pass that and come down to the outlet system. Is there any point above the mouth of the Red River where the so-called outlet system would be feasible or practicable?—A. No; I don't think there is, because at any point above Red River the water would all have to come back into the river again.

Q. And applying the outlet system to the Atchafalaya, or Bayou Placquemine, or Bayou LaFourche, or the so-called Lake Borgne outlet, or any other of those bayous below there, even if such a system were otherwise feasible, could not give relief of any material consequence against the floods above the mouth of the Red River?—A. No; it wouldn't give any relief.

Q. It might for a few miles upstream, above the Red River, but it couldn't extend so as to relieve these floods and crevasses like we had last spring?—A. No; it wouldn't give any relief there at all.

Q. So that if the problem in hand was the question of relieving against the floods and crevasses that we had last spring, extending from Cairo down to the Biggs crevasse there on the Tensas Basin, the outlet system couldn't have any bearing upon it in any event?—A. I do not think it would have any bearing whatever.

Q. So on that branch of the question, what, in your opinion, would be the best plan and method of repressing and relieving against such floods as we had last spring?—A. In the lower river?

Q. Yes, from Cairo down.—A. I think the most feasible plan, the one that offers the best prospect for success, and one of the cheapest and within a reasonable limit of expense, would be the levee system.

Q. Would you supplement it by anything else, Major?—A. I do not think that I would. I do not think that there would be anything gained by it. The Atchafalaya—which takes off quite a large proportion of the river, and it has been doing so for a great many years—of course I would not stop that up, I would let it go on as it is; but I do not think that anything would be gained by attempting to enlarge it and allow a larger proportion of the water to go down through there, because it would only result——

Q. Could anything be accomplished by diverting the river into the Tensas Bayou and letting it run down? That empties into the Red River near the Atchafalaya, doesn't it? Could anything be accomplished by diverting the water into the Tensas?—A. No; I do not think anything could be accomplished there at all—that is, for the relief of the lower river.

Q. What is the approximate length of the Tensas River from where the water would be diverted?—A. Do you mean the basin?

Q. Yes.—A. This is a continuation of the upper Tensas district down to the mouth of the Red River. A levee is continuous from the upper end, opposite Warrenton, Miss., down to a point 5 miles below Fairview Landing, a distance of 126 miles, leaving a gap of 30 miles that is unprotected.

Q. Well, does the lower end of it extend to near the Atchafalaya?—A. The lower end of the levee is within 30 miles of it.

Q. If you should divert the water into that Tensas Basin you would have to levee that also, wouldn't you?—A. Divert the water into it?

Q. Yes.—A. You would have to protect it by back levees, then.

Q. So nothing would be gained by that?—A. I don't think there would be anything gained by that. And if you put any more water into the Atchafalaya it would necessitate raising levees down there, and you would have four lines of levees to build, instead of two, besides the injury you might do to the navigation of the river.

Q. They are building a lock, are they not, at the mouth of the Plaquemine?—A. Yes.

Q. To hold the water back into Bayou Plaquemine?—A. Well, more to enable steamboats to get through—more for the convenience of navigation.

Examined by Mr. BERRY:

Q. Major, do you believe that that river can be leveed from Cairo down to the Passes at a reasonable cost, so as to practically confine the river between the levees in time of high water (barring accidents or breaks, or something of that kind, that ought not to occur)?—A. Certainly. I believe that the levee system, as we are now pursuing it, will take all the water of any probable flood down there. During this last flood all the gauges below New Madrid showed a higher stage of water than any previous record we have along the river, and the whole of that flood, you might say—practically the whole of it—passed through between the levees, in their imperfect state, between the Red River and the mouth of the Mississippi. There was only one little break in that stretch, and that occurred after the flood was off, just below Baton Rouge. It was caused by a crawfish digging a hole through the levee. The proportion of the length of the crevasses to the whole length of the levees is very small. From the information now at hand it appears that there were approximately 1,377 miles of levees on the two banks of the Mississippi River between Cairo and the Head of the Passes, and that the recent flood caused breaks in these aggregating in length only 8.7 miles, which is about sixty-three one-hundredths of 1 per cent of the whole line—less than 1 per cent of the whole length of the line of levees. The crevasses during this high flood, taking the whole of them into consideration, covered less than 1 per cent. Now, then, these levees, understand, are in an imperfect condition. If we can, by the expenditure of a few millions more, put them in a perfect state, I think we can safely say that we can protect that country down there, by the levee system, from any flood equal to what we have record of yet.

Q. There has been an estimate of the probable cost of that, Major. What is that estimate?—A. That estimate is in a report of a subcommittee of the Mississippi River Commission, in the annual report of 1896, and is, I think, about $18,000,000. The commission say this year that they think, from the data they will collect from the results of this last flood, they will be able to get at the figure more definitely, and they also express the opinion that it will not exceed that estimate.

Q. Has the flood of 1897 tended to lessen or to increase the faith of the commission and of the engineers who are familiar with the river in the levee system?—A. I could not speak definitely for anybody but myself. I have never heard any of the members of the commission express themselves otherwise than as I express myself—that they have faith in it. They have all signed a report to that effect.

Q. Well, the breaking of the levees in the manner in which you have stated, has that in any way lessened your belief in the levee system?—

A. No, not at all; because we know what the cause of the breaking of those levees was. The reason there was not more damage done was because of the temporary work that the people put on the levees down in that lower region. If they had stood by and done nothing of course the water would have gone over them a great deal more than it did. But the United States authorities and the local authorities were very active during those times, and, by putting temporary works along the tops of the levees, and every man, woman, and child taking an interest in it and working, they kept the water from overflowing more than it did. The levees down there are not as high, by any means, as is contemplated.

Q. Is it not a fact that if there had been no levees there thousands of acres of land which was not overflowed would have been covered with water?—A. There is no doubt about that.

Q. You say it has been the general impression of the commission that to close the St. Francis Basin before the levees are improved in the lower river, might tend to break those levees. Has that been the theory upon which the commissioners have acted heretofore?—A. I don't know that the commission has expressed itself definitely on that. The general idea is that the levees down below ought to be raised to a proper height before we commence to close in too much above.

Q. But you say, in answer to Senator Nelson, that Captain Pharr, of the St. Francis levee district, contends that the fact that the St. Francis Basin was open last spring tended to increase the flood tide below the mouth of the St. Francis more than it would have been if it had been closed?—A. That is his argument, as I understand it.

Q. And you think that that may or may not be true, but you have not yet formed a definite conclusion?—A. I have not come to a conclusion on that point.

Q. Has the commission been closing the breaks in the White River Basin since the flood subsided?—A. That I really could not tell without looking up the records.

Q. I wanted to ask you, Major, when a crevasse forms, for instance in the lower river, how far above that break or crevasse is the water lowered, if any?—A. That I could not say, either. I could not give you any definite information. I think, though, that there are among the records some definite data on that subject. It may be in some of the appendixes. I know the subject has been frequently investigated. The flood height would be lowered for a certain distance above the crevasse.

Q. But comparatively a short distance?—A. Oh, yes; it would be a very short distance. It might protect a few plantations a few miles above. We know, for instance, that in this last high water the river was lower at Memphis, opposite the St. Francis front, than it would have been had that whole front been closed.

Q. I want to ask you if confining the river in a narrow channel tends to lower the bed of the river or to raise it?—A. It tends to lower the bed, to scour it out, in any special locality.

Examined by Mr. GALLINGER:

Q. You heard the testimony of Colonel Stickney in reference to the work that is now being done in the line of dredging the river, did you not?—A. Yes, sir.

Q. Could you state to the committee approximately the cost of the dredges, the cost of the auxiliary plant, and the amount of work done in the line of dredging, up to the present time?—A. For dredges and

dredging, up to June 30, 1897, $707,109. I get that from the report of the Mississippi River Commission for 1897.

Q. That includes, then, the six dredges already built, and the expense of the work of dredging?—A. That includes the amount that had been expended up to that time in procuring the dredging plant and in dredging operations. That includes the cost of the two dredges, the *Alpha* and the *Beta*, and the dredging, and partial payments on the *Gamma* and *Delta*, delivered since June 30, 1897.

Q. I wish you would look up the cost of all the dredges and the auxiliary plants, and the cost of dredging, up to the present time.—A. During the fiscal years ending June 30, 1893, 1894, and 1895, there was expended upon the experimental dredge *Alpha* $150,838.96. This includes its original construction, the cost of alterations, experiments, dredging operations, and its care during those years.

In the fiscal year ending June 30, 1896, there was expended the sum of $271,487.74 in dredges and dredging. Of this amount $199,581.25 was paid the contractor on account of the dredge *Bêta*. The balance, $71,906.49, was expended in operating expenses of the *Alpha* and *Bêta* and in their repair and care during the year.

In the fiscal year ending June 30, 1897, $284,782.46 were expended for dredges and dredging. Of this amount $19,201 was paid in final settlement of the contract for the *Bêta*; $67,787.20 was paid on the contract for the dredge *Gamma*, and $96,427.20 on the contract for the dredge *Delta*. The balance, $101,367.06, was expended in operating expenses of the *Alpha* and *Bêta* and their repair and care during the year.

It thus appears that the amount paid the contractor for the dredge *Beta* was $218,782.25. The contract price for the dredge, including premium earned, was $259,102.50; $40,380.25 has been withheld on account of nonfulfillment of contract in essential particulars.

The dredge *Gamma* has been completed and delivered since June 30, 1897, at a contract price of $85,530.60, and the *Delta* at a cost of $124,940. There are two dredges now under contract but not delivered, one to cost $102,000, the other to cost $106,000.

The above statement relates to the dredging operations directed by the Mississippi River Commission.

For the improvement of the low-water navigation of the river between the mouths of the Missouri and Ohio rivers two dredges have been provided, one at a cost of $18,000; the other, $22,000. These are of an inferior class.

Contracts have been made for two first-class steel-hulled hydraulic dredges. These are to cost $102,400 each. They have not yet been delivered.

Q. Do you agree with Colonel Stickney, that this expenditure of money for dredging has been of but temporary advantage to the river?—A. Yes; it wasn't designed to be anything else than temporary. It was for temporary aid to navigation.

Q. And do you think enough advantage to navigation has resulted to warrant this outlay of perhaps nearly $2,000,000 up to the present time?—A. I think it will eventually warrant the outlay. You must remember this outlay is principally for the plant, and the plant will last for several years. That outlay is for the special benefit of navigation at low water. These channels that we dredge are not expected to be permanent. As soon as the water rises sand will settle down and fill in the channels again. If we have several small rises during a low-water season we may have to go over these channels two or three times. This

s all for the benefit of navigation, and is just what these steamboat people and those interested in navigation seem to want. They went before Congress and secured legislation to that effect—compelling the Mississippi River Commission to do this. These dredges are only (you might say) just commencing their operations; this is practically the first season, and those who are in charge of them have hardly got the thing well in hand yet so as to work them to the best advantage. But I don't agree with Colonel Stickney in what he says about the futility of dredging. It has been demonstrated in our past experience that this bank revetment is going to hold the river, but the cost of improving by this means is going to far exceed the amount that Congress would be willing to appropriate for that purpose. Dredging was the next best thing that we could come to.

Q. I would like to ask you your opinion as to the probable aggregate cost of carrying out in its entirety that system of bank revetment.—A. My investigation of the matter goes to show that the least cost of any of this revetment that is in any degree permanent has been about $30 per foot. If I were going to estimate it, I would put it higher than that; I would put it even $40 or $50 a foot. Now, there is a distance of 700 miles between Cairo and Natchez where one side or the other of the river would have to be revetted at some time or another, and after that revetment is in it has to be taken care of. The revetment would cost at least $250,000 a mile (that is, by any system we have yet tried and found to be permanent), and you would have to multiply that by 700. That would be somewhere near $175,000,000; and it would take nearly 10 per cent of that each year to watch the revetment and keep it in place after you got it there. So it is impracticable, you see, to try to carry out that system.

Q. I was about to ask as to the commerce on the Mississippi below this point. How many through lines of steamers, or how many steamers, ply regularly?—A. I could not tell you that without looking up some of the records, but there is enough commerce to warrant any reasonable amount of expenditure—anything we would do in the way of dredging—$1,000,000 a year, for instance. We would not, of course, expend nearly that much after these dredges are done, and in addition to this dredging we could do a good deal of temporary work which would help it along. I am doing temporary work in my reach of the river from here down to Cairo, and getting very good results, by putting in what we call temporary jetties. The estimated cost of dredging, after we get all the dredges that we contemplate building, is about $358,000 to $360,000 a year. Now, that is all for the benefit of navigation.

Q. Can you tell me, Major, as a matter of fact, whether the river commerce is increasing or decreasing?—A. For a few years (up until a year or two ago) I think it was not so large as for several years before that time, but I think within the last two or three years the tendency has been to look up. There seems to be a movement on foot now toward organizing barge companies to take grain from here down to the mouth of the river. I think this reach of the Mississippi River is worthy of improvement to the extent that is contemplated by the present project.

Examined by Mr. NELSON:

Q. The flood of the Mississippi River above Cairo, at its high-water stages last spring, was less than it has been at other times?—A. Yes.

Q. It was rather below the ordinary high-water stage?—A. Yes.

Q. And at no time did the Ohio get as high as it had been on pre-

vious occasions; is that true?—A. That is true, so far as we know from the records.

Q. Then, under those conditions as to both streams, how did it happen that the flood of the combined streams was of a more aggravated character, caused more crevasses below, than it had done heretofore?—A. Because of the junction of these high waters.

Q. Simply that?—A. I read you from the record here, the very highest water in the Ohio River, for instance at Cincinnati, did not occur at the same time that the very highest water occurred in the Cumberland or the Tennessee. Now, then, if the water from those three rivers had come down to Cairo together (those three high waters), it might have resulted in a much higher stage of water than is of record at Cairo.

Q. But, even at Cairo, the high water wasn't as high in the Ohio as it had been at former floods?—A. Yes; I know. But you understand the Cumberland and Tennessee empty into the Ohio River above Cairo. Now, then, if the high waters from those two rivers had come along at the same time as the high water came down the main Ohio River, and came down together at Cairo, although the water might not have been as high in either of them separately as it had been at former times, they would make a higher stage of water for the Mississippi at Cairo, because they came together.

Q. I don't think you understand me. I stated that the Ohio at Cairo was not as high during its high stages last spring as it has been on previous occasions. Isn't that correct?—A. Yes, sir.

Q. And the same is true as to the Mississippi?—A. Yes, sir.

Q. That being the case, how came it that the flood below the junction of the two streams seemed to be higher, or caused more damage, than in previous years when the floods have been higher both in the Mississippi and in the Ohio?—A. According to the records, it lacked only six-tenths of a foot of being as high as it had ever been before.

Q. There wasn't much difference, but how came it? The difference was in favor of the flood of this year, wasn't it—that is, it was less this year?—A. Yes.

Q. How came it that, being less, it created greater havoc below?—A. I can't explain it, except on the theory of the second flood coming down on top of the other.

Q. Simply because one flood chased the other?—A. Yes; that made it of longer duration, and those levee banks would get saturated with water, and when water is against them they get weak and are apt to give way.

Q. Isn't it a fact that one of the causes was, that of recent years there has been a closing of the basins below—didn't that have some effect?—A. Yes; I think so.

Examined by Mr. GALLINGER:

Q. Isn't it a fact that a flood accompanied by high winds would be more disastrous than a flood during a season of calm?—A. Certainly. That is, where they have their great trouble during these high waters along the lines of the levees. If the water is nearly up to the top of the levee and there comes a high wind across the river against that embankment, it raises the river a little higher on that side, and then the waves keep lapping there, and all those things tend to weaken a levee; and steamboats are liable to be driven up against it.

Q. Could you state whether or not the winds were more troublesome during the flood of this year than they have been in former years?—A. I could not.

Examined by Mr. BERRY:

Q. If at the time of the high flood tide in the lower river there were continuous rains in that section falling upon the levees, at the same time or just previous to that time, would that have a tendency to soften and weaken the levees?—A. Yes.

Q. And they had almost continuous rains on the Lower Mississippi about the time the flood tide there came on?—A. Yes.

Q. Is it a fact that where there is a crevasse or an outlet made there is a tendency to drop the silt and sand and create a bar below the break?—A. Yes, sir.

Q. That break on the Mississippi side where so much water went out, when it got around and came back into the river, didn't it raise the lower river below where it came into it again?—A. Do you mean down at Vicksburg?

Q. Yes.—A. There was a break below Vicksburg which caused a lowering of the flood level there for a few days. Our records show that at Vicksburg the river reached 49.4 on the 1st of April. This was the maximum for the water coming directly down the river. After this it fell slightly until April 6, when it began rising again from the water which had come through the crevasses above and was returning to the river by the Yazoo bottoms. This rise continued steadily until April 16, when a head of 52.5 feet was reached, which is 3.4 feet above that of 1890, the previous highest stage that is a matter of authentic record. On that date breaks occurred in the levee on the right bank of the river just below Vicksburg, which checked the rise and caused the water to fall very slowly. The water continued at practically 48 feet on the gauge, or above, from March 26 to May 22. How much above this maximum it would have gone had these breaks not occurred can not be determined definitely. The case is similar to that at Helena.

(Further examination of this witness suspended until 9.30 a. m. October 29.)

Examined by Mr. NELSON:

Q. I want to read this to you in view of the questions I asked you last night and the answers you gave, and to ask you if you still adhere to your statements of yesterday. This is from a report of William Starling, chief engineer Lower Yazoo levee district, Yazoo, Miss.:

Effect of new levees upon the flood heights. It is not only the magnitude of the flood of 1897 which has made it of surpassing importance to engineers of the Mississippi service. The widespread damage which this wrought, while great, yet is not without a parallel. Its principal interest to the engineer is due to the experience which has been derived from the wholesale closure of entire levee tracts and the extraordinary elevation of its high-water line consequent thereon. There are two of the great basins into which the Mississippi Valley is divided which have only recently been protected to any extent by levees. These are the St. Francis and the White River basins. The former was closed during the last three years, or since the flood of 1893, to a distance, measured along the river, of 120 miles. There still remains a gap of about 100 miles. The White River Basin has been undergoing a gradual process of closure for several years. In 1893 there was a gap of about 15 miles, extending between points 330 and 360 miles, respectively, by river, below Cairo. In 1896 this gap was closed and the line of levee was made continuous from the hills of Helena to a point 8 miles above the mouth of the White River.

Now, I call your attention particularly to this:

It is to the building of these lines, and to the maintenance of the lines previously existing until a late period of the flood, that the unparalleled stages attained by the water have been due.

That is Starling's opinion, and you are not only at issue with Stickney, but with Starling on that point.—A. No; I don't think we under-

stood each other on that question last night. I was talking of the paper submitted by Mr. Pharr, who is an engineer in the district above Mr. Starling's, and the engineer of the St. Francis front—that is, the State engineer—in which he sought to show that the closing of the St. Francis front would not have raised the water any higher at Helena than it was during the flood of 1897, and that even if it had been closed the water at Helena would not have been any higher than it was. That was his argument. And I said that while I was not prepared to admit that altogether, that I thought there was a good deal of force in his argument.

Q. Last night, as I remember it, I called your attention, first, to the fact that the flood stage in the Mississippi River above Cairo was not as great at the time of the flood below as it had been in prior years; was at an ordinary stage, comparatively speaking, and that the Ohio was not quite up to the maximum of former floods; and then I put the question to you, How it came that the flood was so big below and caused so much damage, and in your reply to that you never took account of this fact that Starling calls attention to—the great closure of the river basins that has been taking place in recent years. You seemed to overlook that fact, and gave no weight to it at all. That is where I disagreed with you last night.—A. That fact must, of course, have weight.

Q. Well, you wouldn't admit that last night.—A. Oh, yes; I don't see how I could help admitting that, because that has been demonstrated by this last flood and by other floods and from what Colonel Stickney said—that if you close these basins by levees, and do not let the water go in, there must be a higher flood stage along the front of those basins than there was before.

Q. Now, that was exactly the drift of my questions last night.—A. Our records all go to show that the water was lower at Memphis, which is in front of the St. Francis Basin, on account of the water going over into the basin, than it would have been if it had all gone down the river. But when you get down to Helena, where the water from the basin and from the river came together, there would be practically no difference in the height. I will show you right here on the map what I mean. I do not think we have understood each other about that. Here is where the levee commences. This is the St. Francis Basin. Here is Memphis. Here is Helena. Here is the St. Francis River—that is, above Helena. Now, there is a bluff that comes down to the shore near Helena, and there is a high levee all along here that was not overflowed (which was equivalent to a bluff), and the water had to all go through here.

Q. Well, this is the point I want to call your attention to, Major: Here is the upper end of the St. Francis Basin.—A. Yes.

Q. Now, suppose at this point the river spreads out into what I should call two channels, one the main river and the other back in the basin. Now, in order that this can aggravate the flood at all at Helena, the waters must unite there at practically the same time. If the flood here [pointing] came in much later, in the nature of the case it could not raise it above what it would be in the channel below; isn't that so? Unless you assume that these two currents, the one in the main river and the one inside of the basin, keep the same pace and reach the point below there where Captain Pharr says the water would be equally high, in the nature of the case the flood could not be as high in the river there?

Mr. BERRY. Senator Nelson, this statement of Captain Pharr, as I understand it, is that owing to the fact that this spring there was a

ond rise in the river, the delayed water in the St. Francis Basin came ; at the mouth of the St. Francis River just above Helena at the ne time the second rise got down in the Mississippi to that point, d the two uniting there made it as high or higher below the mouth in it would have been if all the water of the first flood had gone on ough the main river.

The WITNESS. That is the idea.

Q. Isn't it a fact that if this basin was open, the water that went er into the basin would, in the nature of the case (going over ground ere of various elevations, through trees and timber and everything se), the water would, spreading over that basin, move down the basin ower than the water in the bed of the channel?—A. Oh, yes.

Q. And that the two currents couldn't meet at Helena at the same me?

Mr. BERRY. The first water that went into the St. Francis Basin ame out at Helena precisely when the second rise came on in the main ver, as I understand it.

The WITNESS. Suppose that overflow continued until this basin got ractically full, and that the water in the channel and in the basin were the same condition, excepting that the water in the main channel ould go down faster; and suppose the flood continues long enough for hewater to get out of the basin and into the river before it goes down; en you have no advantage here at Helena, where it comes out, from hat you would have if the basin was not open.

Q. Well, you would have the water distributed over a greater area. an if the basin was closed, manifestly?—A. Well, you see it is going ith a slower velocity down here, but when you get down where it has l got to pass through——

Q. Now, the last wave wasn't as high as the first; isn't that so?—A. es.

Q. In the Ohio it wasn't?—A. I think we mention there (in the port) that the first wave was higher than the other. The amount of e water has to be taken into consideration, as well as the height of e gauge.

s these flood waters passed into the Mississippi, they resulted in a maximum ight of 51.6 at Cairo, March 25, 1897. The crest of the first wave had scarcely sed by when it was followed by another which didn't reach quite this height. e highest previous record at Cairo was 52.2.

Q. So you see you are taking the fact that the last wave was less an the other. You have got the basin's share of the last freshet to pplement the river's share of the first wave, and those two combined n't equal the combined waters of the first, if they had been in the annel. You can figure that out, can't you?—A. Well, it may be so, d it may not. There is another question that has to come in there, d that is the amount of discharge. We may have a greater discharge, instance, with a less height of water on the gauge than with a eater height. Take the river here. By discharge computations taken low-water stage, we find there is more water going down now than ere was two or three years ago (when we took other observations) th a height of gauge a foot and a half or 2 feet higher. It is because the sand having been washed out, you know.

Q. Well, Major, to sum up, in your opinion did the closing up that s been going on in the St. Francis River Basin have any effect upon e flood of 1897, in increasing its high-water level, or did it not?—A. m inclined to believe it did not.

Q. All right. That is the way I understood you last night. And is that you differ with Starling and Stickney; isn't that plain?—A. Well, I don't know whether Colonel Stickney has taken into consideration these other facts so much as I have or not.

Examined by Mr. BERRY:

Q. Is there anything you have not already stated that you would like to state, Major?—A. Well, there is one fact about the improvement of the river at the Lake Providence and at the Plum Point reaches, that was referred to yesterday, in regard to which I do not think the committee would get a proper impression, from the evidence, of the state of affairs that exists there now. Those two reaches were determined upon by the commission some years ago for radical improvement. There was a great deal of money expended there (I don't recall the figures now, but we have them in the records) at these two places, and especially at the Lake Providence reach, which resulted in a great improvement of the channel in that locality; but in consequence of their having to abandon this bank protection, the position of the channel has changed, but it has not got back to anything like the bad condition it was in before. That is brought out in the report of the commission.

Q. Where is the Lake Providence improvement?—A. It is above Vicksburg. It is one of those bad reaches that the commission undertook to improve at the beginning by various devices. There is 35 miles of river that we call the Lake Providence Reach. The lower end of it is about 50 miles above Vicksburg.

The depth of its navigable channel at its crossing during low water was at times reported to be only 4½ to 5 feet [that was before the improvement]. The width of the river in this region was excessive. The original project provided for giving the low-water channel an approximately uniform width of 3,000 feet by constructing contraction works, closing chutes, and preventing erosing in concave banks. Instead of covering the entire reach of 35 miles, as was originally intended, the work was confined to a reach of 20 miles. The bank protection and contraction works are now practically gone; the former because a method of construction of sufficient width and strength of mattress had not been used, and the latter because their continued usefulness was dependent upon the ability of the former to protect adjacent and opposite banks. When the revetment failed this involved the destruction of the contraction works. A marked improvement in the low-water channel in this locality was effected by these works. Notwithstanding that they are now practically obliterated, the channel has not yet reverted to anything like its former conditions of difficult and almost prohibitory low-water navigation.

That is the condition down there, notwithstanding the works were practically obliterated. There is a very good channel there now as compared with what it used to be.

Q. Is there anything else you would like to state, Major?—A. Does your investigation take into consideration low-water navigation by this temporary means we were speaking of? I have in my reach of the river some work that has been quite successful.

Q. Could these hurdles that you find between here and Cairo be applied successfully to the lower river—below Cairo?—A. Something of that character is what they did try down there, you know.

Q. That is that expensive work that you spoke of?—A. That would be very expensive there, but in my reach of the river the conditions are quite different. We find we can do temporary work successfully and within a reasonable limit of expense. This temporary work I was speaking of is like this [referring to a map]: Here is supposed to be a wide piece of river. At low water the channel is around in various places and we want to contract it, so we put in what we call a temporary dike, made of piles driven from 15 to 20 feet apart along a line like

this [indicating]; then there are pieces put on along the top of these piles and fastened to them. Leading down from these to the bottom are what we call panels. These are put down leaning against the pieces. They contract the water into this channel, get it all together, and it scours a deeper channel across a bar that might happen to be down here. We are working that now in my reach of the river. It has been quite successful, and I suppose to a limited extent it might be used in the river below. That is one of the temporary expedients we have.

Capt. HIRAM M. CHITTENDEN, sworn, testified as follows:

Examined by Mr. NELSON.

Q. You are the secretary of the Missouri River Commission?—A. Yes, sir.

Q. Have you any connection with the Mississippi River Commission?—A. None.

Q. You have never been on that commission?—A. No, sir.

Q. And you are not acquainted with it nor its work?—A. Only in a general way.

Q. How long have you been secretary of the Missouri River Commission?—A. Since a year ago last July.

Q. You belong to the Army?—A. Yes, sir.

Q. How often does the Missouri River Commission meet each year?—A. The commission met once in the fiscal year ending June 30, 1897. It has met twice this year, so far.

Q. How long did each meeting last?—A. The meeting a year ago lasted three days; the first meeting this year lasted three days and the last one one day. Several informal visits have been made by the members of the commission to the various works under their charge.

Q. The year before that how long?—A. The year before I was not secretary of the commission and I could not tell without looking up the records.

Q. You were not with the commission then?—A. No, sir.

Q. What is the character of the commerce of the Missouri River from its mouth to Kansas City?—A. It is what you might call local, irregular commerce.

Q. Are there any regular lines of boats plying up?—A. No, sir.

Q. Nor any through steamboat navigation?—A. I think none at all.

Q. Either last year or this year?—A. I think that prior to last year there have always been some boats, one or more, doing through business to points well up the river. The last boat doing this kind of trade was destroyed in the St. Louis cyclone in May of last year. Since that time there has been no regular through steamboat trade.

Q. There is nothing, then, except a few little local steamers?—A. Local, irregular traffic, that is all, except on the Osage River, where there is a boat running regularly.

Q. How far up?—A. At extreme low water it goes to the site where we are building a lock, about 7 miles above the mouth of the river. At ordinary stages it goes much higher. The river is navigable to Osceola, 228 miles.

Q. Is the Osags River on your line of improvements?—A. Yes, sir; it is under the Missouri River Commission.

Q. Is there any navigation on the Gasconade River?—A. Yes, sir.

Q. Regular steamboat navigation?—A. Yes, sir. There are at least two steamboats doing regular traffic on the river, and one line of flat boats. The business in tie rafting is one of considerable magnitude,

regularity, and importance. Both the Gasconade and Osage rivers pass through important sections of country which are entirely without railroad facilities. The business on each would be considerable, but for insufficient depth on the shoals in low water. Both streams are susceptible of such improvement as will render them navigable during the entire season at a moderate outlay.

Q. Do those boats that ply on the Gasconade and the Osage go down below the mouth of those rivers?—A. They do whenever there is occasion. Generally they simply bring the traffic down to the railroad.

Q. They don't ply down here to St. Louis?—A. Not ordinarily.

Q. Are there any so-called harbor improvements that you have been making along the river from the mouth to Kansas City? By harbor improvements I mean those improvements that are made, either by the commission or by legislative order, in front of towns or railroad bridges. For instance, I call your attention to the last harbor bill. You remember there was something appropriated for the harbor at Bismarck and some other places?—A. Yes, sir.

Q. Have you made any such improvements?—A. No, sir. Nearly all the special work on the Missouri River has reference to the protection of localities against erosion.

Q. Well, what you call local improvements I would call harbor improvements. Those local improvements are generally opposite towns, are they not?—A. They are ordinarily designated by the names of the towns nearest which they are located, but very rarely do they occur right at a town. Generally they have very little reference to harbors, I think.

Q. Well, they are near towns?—A. Yes; generally near some town.

Q. These local improvements that you have been engaged in have been made mainly by legislative direction, have they not?—A. Yes, sir; I think entirely so.

Q. Not according to any systematic plan of the commission?—A. No, sir.

Q. Can you state the principal places where you have had these so-called local improvements?—A. I think I can recall most of them where work has been done within the past few years: Omaha, Council Bluffs, Nebraska City, Atchison, St. Joseph, Leavenworth. There have been works in the past at Kansas City, but that was before my time here.

Q. None now?—A. No, sir. There are also works going on this side of Kansas City, as, for example, at Glasgow, Miami, Little Blue, Howards Bend.

Q. You have divided the river from here to Kansas City into three reaches, as I understand?—A. Yes, sir.

Q. And on the middle reach, so called, there have been no systematic improvements?—A. No, sir.

Q. On the upper reach there was some systematic improvement some years ago, but not lately?—A. None lately.

Q. And the systematic improvements have been going on wholly on the lower reach of the river?—A. Yes, sir; on the upper part of the first reach.

Q. The reach extends from some little piece above Jefferson City to the mouth of the Osage?—A. The work so far done extends from above Jefferson City to the mouth of the Gasconade. The reach itself extends to the mouth of the river.

Q. I mean the work—from a little above Jefferson City to the mouth of the Gasconade?—A. Yes.

Q. A distance of how much?—A. About 45 miles.

Q. What has been the effect of the work you have carried on?—A. I think it has been very satisfactory, so far as results are concerned.

Q. Deepening the channel?—A. Yes, sir; and confining and holding the river. As to expense, that is a different question.

Q. I understand the expense has been about $44,000 a mile?—A. Somewhere in the neighborhood of $44,000 a mile.

Q. And what is the mileage?—A. As I stated before, about 45 miles.

Q. Do you think the demands of navigation would warrant the continuance of the improvement on that reach of the river at the same rate of cost?—A. Apart from the preservation of the land along the river, it may be doubtful if it would.

Q. Isn't it a fact that the chief value derived from this work has been the preservation of lands at different points rather than the improvement of navigation?--A. So far as the results at present achieved are concerned, I think so.

Q. And for the purposes of navigation an expenditure at such a rate would not be warranted?—A. That question is hardly susceptible of answer by a simple yes or no. If it were a matter solely of the commerce actually carried on at the present time, the answer would have to be in the negative. But that would be a very short-sighted view to take. In the first place, the work so far done can not yield its full fruit until the entire improvement of which it forms a part is complete. Suppose, for example, that the Missouri Pacific Railroad, which practically parallels the river from St. Louis to Kansas City, were completed only between Jefferson City and the mouth of the Gasconade River. It would be absurd to estimate its commercial importance when complete by the business done when only a small fraction of the entire line is finished. So with this river work. If a navigable condition prevailed from the mouth of the Missouri to Kansas City, such as has resulted from the systematic improvement so far carried on in the first reach, I have no doubt that there would be an important regular commerce on the river. There is every reason to think that such would be the case.

In the second place, it has always been one of the recognized arguments for the improvement of our navigable waterways that they act as effective regulators of freight rates on railroads and powerful obstacles in the way of extortionate or discriminating charges. My observation on the Missouri River confirms this view, for I have experienced a sharp advance in rates in the shipment of Government freight consequent upon the disappearance of a regular packet from the river. The difference in this respect between a practically nonnavigable stream and one of an assured depth of, say, six feet at low water would certainly be very important.

These two considerations, viz, the direct results to be expected from a completed system in the matter of freight actually carried and the indirect results in the matter of freight rate regulation, must be given due weight in answer to your question. They are not considerations that can be reduced to definite figures, but I am of opinion that they are of sufficient importance, in connection with the reclamation and preservation of the bottom lands, to justify the systematic improvement of the river at least as far up as Kansas City.

Q. Did you hear Colonel Stickney's testimony?—A. No, sir.

Q. You are familiar with his new idea of building so-called bank heads?—A. Yes, sir.

Q. You have seen that tried and tested?—A. I have seen the one that has been built. I can't say that I have seen it tested, because I don't think time enough has yet elapsed to give it a fair test.

Q. You haven't formed any opinion, then, as to what it will lead to?—A. So far as demonstrated results are concerned, I have not. In theory the system is certainly very plausible, and the great saving in the cost of river improvement which its successful application would insure justifies the thorough trial that is being made of it. As to its ultimate value, it requires more time than has yet elapsed to pronounce upon that.

Q. Please state the nature of the improvements you have been carrying on under your plan.—A. Under my own direction?

Q. Well, I mean the general system of work that has been going on in your reach of the river.—A. It has consisted in holding the river on adopted lines mostly by means of dikes extending out from the bank.

Q. Those dikes consist of piles driven from the bank out into the river, on the shallow side of the river?—A. I can't say as it is always the shallow side. Some have been driven in very deep water.

Q. And then filling in between with poles or willows?—A. By putting mats on the bottom, and then making screens of poles extending vertically in order to arrest the flow of the water and cause a deposit below.

Q. To catch the silt.—A. Yes, sir.

Q. And on the other side do you build revetments?—A. No, sir.

Q. Or riprapping of any kind?—A. No, not generally. As a general thing where those dikes are built the trend of the river is such as to hold it in against this work anyway, and we don't ordinarily need anything on the other side. There are, however, important exceptions to this rule.

Q. So most of your work has consisted of dikes?—A. Yes, sir; there is also a good deal of other work, such as revetment work pure and simple, sometimes in connection with the dike work, and sometimes in detached sections of the river.

Q. Have you had much pure and simple revetment work?—A. Taken altogether there has been a good deal.

Q. What is the nature of that?—A. Brush mattresses extending well down into the water and covered with stone.

Q. Sort of a riprapping on top?—A. Yes.

Q. Captain, can you think of any method by which anything could be done to the Missouri River which would tend to lessen the floods on the Lower Mississippi River, either by reservoirs or anything else?—A. There is nothing that could be done to the Missouri River that would have much effect on the great floods of the Lower Mississippi, for only a small part of the volume of these floods comes from the Missouri. Reservoirs might reduce the floods of the Missouri River somewhat.

Q. Could reservoirs be built on the Missouri River that would indirectly affect the matter of floods and at the same time aid in irrigation?—A. Unquestionably.

Q. At what point could such reservoirs be built? Up along the bed of the Missouri River?—A Oh, no. Reservoirs could never be built in the immediate valley of the Missouri River unless near its extreme source.

Q. You would build them on some of the tributaries?—A. Yes, entirely.

Q. It would have to be on the upper tributaries where the waters could readily flow into the arid belt, wouldn't it?—A. That is not necessarily so. Reservoir sites are not confined to the mountains, as commonly supposed. There is a great deal of the western territory where depressions of enormous magnitude exist, in which large amounts of

vater could be stored, well down on the plains, below the natural eservoir sites in the mountains themselves.

Q. On some of those streams which flow from the west into the Mis-ouri?—A. Yes, sir. I think that is true of nearly all of them.

Q. Well, in addition to promoting irrigation, might not those reser-voirs also aid in diminishing or repressing the floods of the Mississippi River?—A. Not of the Mississippi. As I said before, the amount of lood water that goes from the Missouri into the Mississippi, as com-pared with the entire flood discharge of the latter stream, is too small o cut much of a figure.

Q. The chief floods of the Mississippi come from the Ohio, do they ot?—A. Yes, sir.

Q. Are you familiar with the Ohio River and its floods? Have you ver been engaged in work on the Ohio?—A. To some extent; yes, sir. made canal surveys in the State of Ohio two years ago and examined he reservoir question there in that connection.

Q. Are there any points on the Ohio River or any of its tributaries vhere at a reasonable expense reservoirs could be built that would aid n repressing or diminishing the floods on the Lower Mississippi River?—A. I found, in searching for reservoirs to feed canals across he summit between Lake Erie and the Ohio River, where I could store 1,000,000,000 cubic feet. This satisfied the requirements of the canals nd was all I looked for, but I found it without any difficulty and near he very heads of the streams. The estimated cost was about $11 an cre-foot. An acre-foot is the common unit in the Western country; hat is, a quantity of water that would cover 1 acre to the depth of 1 oot. A billion cubic feet contains 23,000 acre-feet and on the same asis would cost $253,000.

Q. How much could you have gotten this for, do you say?—A. It vould have cost $11 per acre-foot.

Q. On what streams was that?—A. This was on the Scioto and Miami rivers.

Q. Could any reservoirs be built on the Tennessee or the Cumber-and?—A. I am not familiar with either stream, but unless they are uite different from any other streams that I have ever seen important eservoir sites can be found on their watersheds.

Q. It is your opinion, then, that reservoirs could be constructed on he upper waters of the Tennessee and the Cumberland and the main ributaries of the Ohio—for instance, the Allegheny and the Mononga-hela—that would be efficient factors in restraining and repressing loods on the Lower Mississippi River?—A. As a simple physical prob-lem it is probable that there could.

Q. I don't exactly mean that, Captain. I mean at a moderate or easonable cost.—A. No, sir.

Q. You don't think it can be done at any reasonable cost?—A. To how what the cost would be, the surplus flood water at Cairo this year (that is, the amount above the bank-full stage) was about 2,300,000,000,000 ubic feet. Now, at a rate of, say, $5 an acre-foot, or $115,000 per illion cubic feet, it would cost $264,000,000 to store this amount of vater.

Q. So, while physically possible, the expense would be so great that t would not be a practical thing anyway?—A. That is it exactly, unless here are other things which the reservoirs could be used for, as, for nstance, out West where they could be used for irrigation. This whole ubject of reservoirs and their influence upon floods I have discussed at onsiderable length in a report just completed under the provisions of

the last river and harbor bill. It gives a considerable array of data relating to all phases of the subject.

Examined by Mr. GALLINGER:

Q. Captain, as to the cost of storing this 11,000,000,000 cubic feet of water—will you kindly restate that.—A. The water was required for the feeding of canals which the Government had ordered surveyed with a view to possible construction. I found the cost to be about $11 per acre-foot, or $253,000 per billion cubic feet.

Q. Of course, the only way it could be made profitable would be by the Government going into the sale of water rights, wouldn't it?—A. Only a limited use could be made of it there for industrial purposes.

Q. On the Upper Mississippi there are 93,000,000,000 cubic feet stored at a cost of about $1,000,000.—A. Yes; the actual capacity of those reservoirs is as you state, and the cost has been only 32 cents per acre-foot. These figures, however, do not convey an entirely correct idea. The maximum storage which it has yet been possible to realize by means of those reservoirs in any one year is less than 40,000,000,000 cubic feet. There has never yet been enough water to fill them in one year. But even on the basis of this smaller storage the cost per acre-foot has been only 74 cents—probably the cheapest storage ever yet realized. The difference between the maximum capacity of these reservoirs and the actual storage realized from them has given rise to erroneous conclusions as to the efficiency of reservoirs in general. It is said that these reservoirs, with a capacity of 93,000,000,000 cubic feet, produce an increase of gauge height on the Mississippi at St. Paul of only 12 to 18 inches, whereas, as a matter of fact, this increase is produced by not more than one-third of the above amount.

Q. Upon what hypothesis could the Government go into the business of storing 11,000,000,000 cubic feet of water at the point in Ohio which you have named, at a cost of nearly $3,000,000?—A. As I said before, this storage was intended solely as a supply for canals leading across from Lake Erie to the Ohio River.

Q. What would be the utility of the canals?—A. That is a commercial question entirely. I brought up the illustration only as an example of the cost of storing water, without any reference to the merits of the particular project with which it was connected.

Examined by Mr. NELSON:

Q. I wanted to see if we could do anything in the Ohio to prevent the floods in the Mississippi, but from those figures I should think we could not.—A. Assuredly not.

Q. Are you acquainted with the Mississippi and its freaks, below Cairo?—A. In a general way, as almost every engineer is. I have never had any duty directly connected with that stream.

Q. But you have given some study and attention to the subject?—A. Some; yes, sir.

Q. You are familiar with the flood stages of the water here last spring?—A. Yes.

Q. What, in your opinion, were the principal and leading factors that caused those overflows and crevasses below Cairo?—A. As to the flood itself it was caused by a period of long-continued and heavy precipitation which swelled the various tributaries to a flood stage. Then, as is nearly always the case in the more disastrous floods of the Mississippi, the floods from several of the tributaries arrived simultaneously in the main stream, or nearly enough so, to unite their effects. It is not often that a flood from any one tributary is alone sufficient to produce disas-

esults in the Lower Mississippi. Concerning the breaks in the although I am not familiar with the subject from personal exami-, I have understood that they were mostly due to the imperfect f completion. Some of these levees, I understand, were put to a test this year for the first time. That they yielded in some under the great strain to which they were subjected is not so matter of surprise as that they yielded so little. I have not tood that the result is regarded by engineers who are familiar ie situation as at all unfavorable to the levee system, but rather erse.

'he water simply became too high, or the levees were not strong ı. I understood from Colonel Stickney that a good many of the ses were caused by the water flowing over the levees.—A. That ably the case. I am not familiar with the details of the subject. Vhat is your opinion as to the best method (if you have formed inion) of repressing the floods on the Lower Mississippi below —A. The opinion I have formed has been that the levee sys-

s the only method?—A. The principal method, at least.

ncreasing the levees; making them stronger and higher?—A. ting them.

Vould you supplement them with anything else, Captain?—A. a very broad question upon which, I think, hardly any engineer wish to commit himself. As you have referred to the subject of oirs in this connection, however, I may mention a suggestion ted in a monograph upon the floods of the Mississippi by James ldon, United States assistant engineer, which forms part of the oir report already referred to. Mr. Seddon suggests the possi- of utilizing the St. Francis Basin as a vast storage reservoir for ion of the flood waters of the Mississippi. As is well known, a erable percentage of these flood waters, in high floods, flows over ie St. Francis Basin and returns again to the river in the neigh- d of Helena, Ark. It is thus withdrawn from the main stream y a portion of its length, and its return may, and has, come at es when it probably aggravated the flood at Helena and below. 'erflow into this basin in a great flood, like that of 1882, is equiv- o a depth of 6.5 to 7 feet upon its overflowed area of about 6,700 miles. The fall in the total length of the basin is about 120 feet. basin could be divided by cross embankments into several basins average depth of say 20 feet, with longitudinal levees to restrict oded area to one-third or less of what it is at present, and if a el of suitable dimensions could be constructed to convey the over to the head of the basin, these separate reservoirs would retain l the flood had subsided. The volume so stored, if added to the ter flow of the Mississippi, would give it an increase of from) to 150,000 cubic feet per second for one hundred days, making v-water discharge of the Mississippi from Helena to the sea at 00,000 cubic feet per second. From Helena to Cairo a slack- system might be provided through the basin itself with a navi- depth equal to that from Helena down.

ntion this possible use of the St. Francis Basin, not as in any serting its practicability, for careful surveys alone can determine ut as a subject worthy of consideration. This basin has in some had a moderating influence upon the floods of the Mississippi indefinite period in the past. Before it is altogether closed t future overflows from the river, it is worth while to inquire if

its former function as a flood reservoir may not be modified and made more effectual instead of being abolished altogether.

Q. In your opinion, would the so-called outlet system furnish any relief?—A. It certainly could not for the upper part of the lower river.

Q. For that part above the Red River?—A. Yes.

Capt. HENRY E. WATERMAN sworn, testified as follows:

Examined by Mr. NELSON:

Q. Captain, you are an officer of the Engineer Corps of the United States Army, with the rank of captain?—A. Yes, sir.

Q. And at present you are the secretary of the Mississippi River Commission?—A. Yes, sir.

Q. How long have you been secretary of the commission?—A. Since September, 1895.

Q. Were you connected with the commission in any other capacity before that?—A. No, sir.

Q. What are your duties as secretary?—A. I have charge of the surveys, discharge work, and gauges maintained by the commission, of the dredges and dredging between Cairo and the Head of the Passes, and other incidental work of the commission. All of the expenses of the commissioners are paid out of my office.

Q. Now, while you have been secretary of the commission, what work of improvement has been done by the commission, outside of the building of levees?—In other words, have you done any other work than dredging on the river?—A. More or less improvement work has been going on on the lower river at various times. That is in charge of three other district officers.

Q. They are not under the commission?—A. They are under the commission in the same way I am.

Q. Tell us in a general way what work has been done on the river outside of the building of levees since you became connected with the commission.—A. Quite a number of important pieces of harbor work have been carried on.

Q. In front of towns?—Q. In front of large towns.

Q. To maintain the banks?—A. Largely for that purpose, I think; not entirely.

Q. To prevent the towns from being undermined?—A. To prevent cut-offs or something of that kind.

Q. In front of towns?—A. Yes.

Q. Can you remember the principal places where there has been harbor work, so called?—A. There is the improvement of New Orleans Harbor, the improvement at the mouth of the Red and Atchafalaya rivers, the improvement of Natchez and Vidalia harbors—this last is to prevent a cut-off just above the harbors.

Q. You have an improvement at Plaquemine, haven't you?—A. That is not under the commission.

Q. That is independent of the commission?—A. Yes.

Q. Then going up the river you have New Orleans, the mouth of the Red and Atchafalaya, and then Vidalia?—A. Natchez and Vidalia together. This is to prevent a cut-off which would destroy the harbors of Natchez and Vidalia opposite.

Q. At New Orleans it is to protect the levees, I suppose?—A. I think it is to prevent a bad caving away of the water front, which is very valuable.

Q. On the New Orleans side?—A. On the New Orleans side and also on the Algiers side.

Q. And what is the object of the improvement at the Atchafalaya and Red?—A. There is considerable difference of opinion among the commissioners themselves as to this improvement, but it is believed, I think, generally that the maintenance of the outlet of the Red River into the Mississippi is necessary, first for the purpose of furnishing an outlet for the extensive commerce of the Red River and its tributaries, into the Mississippi——

Q. There has been danger, then, of the Red River being diverted into the Atchafalaya?—A. Into the Atchafalaya.

Q. And being cut off from the Mississippi?—A. Something of that kind. And there is also——

Q. And the object of the work there has been to keep up the connection of the Red River with the Mississippi?—A. Partially, and furthermore, to prevent the connection between the Mississippi and Atchafalaya growing to an excessive extent so as to cause the Mississippi to go down that way and abandon New Orleans.

Q. In other words, it has been to tie the Red River to the Mississippi, and to prevent the Mississippi going into the Atchafalaya?—A. Yes, sir. It has a restraining effect both ways. In low water the mouth of the Red River is kept open by means of dredging; and, on the other hand, sills have been placed in the Atchafalaya and are maintained there to prevent an increase in the cross section of the Atchafalaya to an alarming extent during floods.

Q. Has there been danger of the Mississippi going into the Atchafalaya?—A. There has been a good deal of talk about it in the past, but I don't think it has been considered of much danger of late. The sills themselves are in very good condition at present.

Q. You put mattress sills in the bed of the river?—A. All the way across.

Q. You are familiar with the so-called outlet system? You know what we mean by that?—A. Yes.

Q. Now, that is about as far as the outlet system could well be utilized, if at all, isn't it?—A. Yes, sir.

Q. At the mouth of the Red River?—A. Yes, sir.

Q. And from there on down it could be used at different points—at Bayou Plaquemine, perhaps, to a limited extent; Bayou Lafourche, and Bayou Manchac, and there are one or two obsolete bayous leading into Lake Borgne and Lake Pontchartrain; but in the nature of the case, those outlets couldn't have any bearing on the floods above Vicksburg?—A. I don't see how they could.

Q. Could they diminish the floods in any degree?—A. I don't see how they could have any effect, except to give relief in the immediate vicinity.

Q. So, aside from all other considerations (assuming that it would be safe and proper as a matter of relief), for the river above Vicksburg those outlets couldn't cut any figure, even if they were otherwise feasible and practicable?—A. I don't see how they could.

Q. Now, going up the river from the mouth of the Atchafalaya and Red, the next is Natchez?—A. Yes; Natchez is above the mouth of the Red River. Then we come to Vicksburg. However, the main improvement of the harbor of Vicksburg at present is not in the hands of the commission.

Q. It isn't in the hands of the commission, but isn't the main improvement to divert the Yazoo into the old bed of the Mississippi in front of Vicksburg?—A. Yes; that is the project.

Q. As I understand it, the Mississippi River has cut across the bend in front of Vicksburg?—A. Yes, sir.

Q. There was an old canal, built by the Army during the war; it is above that, is it?—A. It is above that. The remains of that ditch are still in existence, but the ditch had nothing to do with the cut-off.

Q. But the river has cut off so the port of Vicksburg now is away below the city several miles?—A. I think it is about 2 miles below Vicksburg landing.

Q. And around that bend that has thus been cut off there is an old river bed, and it is proposed to divert the Yazoo River into the lower end of that cut-off?—A. Into the upper end of the old bend.

Q. And thus, by means of the water of the Yazoo, to give a new river?—A. Yes, sir.

Q. But that is outside of your commission?—A. Yes, sir.

Q. So you really have no harbor work there, then?—A. There is a small appropriation still left over in the hands of the district officer for the protection of Delta Point, which is all that remains of the original peninsula. It commenced cutting off at the upper end and kept getting shorter and shorter, and finally they tried to hold it by holding Delta Point and succeeded in doing so. That work is still in there.

Q. What is the nature of that work—riprapping?—A. Yes, sir; it is riprapping; regular bank-protection work.

Q. What is the nature of the work at New Orleans—revetment work?—A. Not continuous revetment work; it is discontinuous revetment work. There are spur dikes at intervals.

Q. With revetments between or on the opposite side?—A. I think generally there is no revetment between at all.

Q. Simply spur dikes?—A. Simply spur dikes built up by layers of mattresses, one upon the other.

Q. Are they on the side opposite the city or on the city side?—A. On both sides. I have an atlas in my office on which is indicated all the work of the commission up to the 30th of June, 1896, showing what is at present in existence and what has been done. I could show you on that atlas at a glance, I think, the work that has been done.

Q. At the head of the Atchafalaya harbor work are matttress sills, aren't there?—A. In the Atchafalaya there have been mattress sills put in, and also a dam put across one branch of the Red River.

Q. What is the nature of the work at Natchez and Vidalia?—A. At Natchez and Vidalia it is the prevention of a cut-off across a neck above Natchez, known as Cow Pen Neck. To prevent this a levee has been built down the backbone of the peninsula to prevent overflow during high water. This levee is purely a piece of river work; it is not an ordinary levee for protection against overflow at all; it is simply to prevent the cut off, to make a higher ridge through there to prevent the water cutting through; and that has to be protected. I think it has been riprapped on the upper side to a considerable extent.

Q. Now, up there at the point at Vicksburg, what is the character of the work you have been doing there?—A. I think there has been nothing done there in a good many years. What has been done there was simply for the maintenance of the old work, in the way of giving additional strength, something of that kind.

Q. Going up the river, is there any work at Lake Providence? Well, there is revetment above the town of Lake Providence; that is, the first harbor work above?—A. This revetment is mainly intended to prevent destruction of a levee across the head of Lake Providence.

Q. And what comes above that?—A. Lake Providence has not had a special legislative appropriation.

Q. The work at these other places has all been done under special

ɔriations?—A. New Orleans, the Red and Atchafalaya, and
ez and Vidalia, have all had separate appropriations from the
ɔriation for improving the Mississippi River.
But they are under the commission, are they not?—A. They are
plans and specifications and recommendations of the commission.
But the Yazoo improvement is not under the commission?—A.
s not under the commission. The work on the Lake Providence
is simply a part of the continuous work of the commission.
Now, what is the next place, going up the river?—A. Greenville
r has had at various times a special appropriation, and under the
it bill a certain amount from the appropriation for improving the
sippi River is directed to be expended on the project at Green-
Harbor. The project at Greenville Harbor is the prevention of
cessive caving there.
That is revetment work, is it, or dike work?—A. There have been
kinds done, but I think it is practically continuous revetment
now.
Now, what other harbor work?—A. Ashbrook Neck and Lake
r front are special localities not provided for by Congress.
Where the commission has put in work?—A. Yes.
Harbor work?—A. At Lake Bolivar it is the protection of an
ive caving of the bank which would destroy an expensive levee
the head of Lake Bolivar, but at Ashbrook Neck it is the preven-
f a cut-off through a very narrow neck. Very expensive work
en done there and very successful work.
As you go farther up, what other points are there?—A. Next we
o Helena Harbor. That has frequently had a special appropri-
and under the present bill a certain amount, I think, of the
ɔriation for improving the Mississippi River is allotted to it.
That is at the mouth of the St. Francis, isn't it?—A. Just below
outh of the St. Francis.
BERRY. You did work at Arkansas City, didn't you?
WITNESS. There has been work done there, but not of recent
that I know of. I think that work is all in good condition.
Has the work at Helena been completed?—A. I don't think it
en; in fact, I think there has been caving below the ends of the
vement.
Is that carried on under a special appropriation or under the gen-
owers of the commission?—A. I think it is carried on from the
l appropriation, but by special allotment of Congress.
As you go on up the river, what is the next point?—A. Nonconnah
That is a special work of the commission. Congress has not
ed it. There are some rocks in the channel that they have
ed the removal of. Then we go to Memphis Harbor, which
es also Wolf River. That is under special appropriation. The
it that has been spent at these places is the amount specified by
ess.
Above Memphis what harbor improvements have you?—A. In the
ust above Memphis—the Hopefield Bend—and then we come into
is known as the Plum Point Reach, which has been very exten-
improved at various times——
At the Plum Point and Lake Providence reaches is where you
done this extensive dredging, isn't it?—A. I haven't got far
h down to get to the Lake Providence reach. I haven't enough
es to do that.
The commission has been doing dredging at the Lake Providence

reach, has it not?—A. I wasn't aware that any dredging had been done on the Lake Providence reach at all. As a matter of fact, during the last four or five years, generally, the low-water navigation through the Lake Providence reach has been in most excellent condition.

Q. Has any work been done on the Lake Providence reach within recent years?—A. This work at Ashbrook Neck and Lake Bolivar front is all in Lake Providence reach.

Q. That is revetment?—A. Yes.

Q. Now, come up to Plum Point, where you have been dredging. Have you done any so-called harbor work there?—A. We have had some dredging to do in Plum Point reach.

Q. No; but dike or revetment work?—A. They are doing nothing of that kind at present, except the maintenance of such revetment work as was in there before. There have been no extensions of late.

Q. You have simply maintained it. Now, going up above Plum Point, what so-called harbor or local improvements have you made, if any?—A. Above that we have New Madrid, which is revetment work in front of the town, to prevent the caving away of the natural bank there.

Q. Somewhere there, either just below or above, is where the river crawled over into the St. Francis last spring, isn't it?—A. Near Cottonwood Point, about 50 miles farther down, was the first large crevasse. It is pretty high ground there at New Madrid.

Q. It was somewhere below there where the river crawled over into the St. Francis basin?—A. Yes; but also above, between New Madrid and Commerce. Hickman and Columbus also had special appropriations for little harbor improvements; I think nothing of late.

Q. Well, at those points there are high bluffs; the only point would be to prevent the river digging under the bank there, wouldn't it?—A. It is simply the maintenance of their river fronts, that is about all.

Q. Now, Captain, aside from these harbor and local improvements that you have detailed, the only improvement on the river itself, since you have had any connection with the commission, has been in the shape of dredging, has it not?—A. Dredging and the building of levees.

Q. Well, I mean outside of the building of the levees and outside of these local harbor improvements, so-called, that you have detailed here, the only other improvement has been the dredging of the river?—A. Yes, sir.

Q. And how much have you been devoting each year to the dredging of the river, on an average, approximately?—A. You mean since I have been secretary?

Q. Yes, since you have been connected with the commission. If you are acquainted with its work further back than that, why state the facts.—A. A regular system of dredging covering the entire river was really not adopted until after the passage of the act of Congress of June 3, 1896.

Q. Before that you did no regular dredging work?—A. Before that one dredge had been constructed and numerous experiments were being made with it, to devise some plan of general improvement.

Q. But no substantial amount of dredging had been done?—A. Yes, sir. For two years previously some very good work was done with that one dredge in the worst section of the river, just below Cairo; but it was operated more as an experiment. What I mean is that no definite plan had been adopted of an extensive system of improvement.

Q. But now you have adopted a plan?—A. Now a certain plan for improvement has been adopted by Congress.

Q. And what is the aggregate amount of expenditure a year for dredg-ıg under the present plan?—A. The allotment for the fiscal year ending une 30, 1897, in cash and authorized contracts was $398,000, and for hat ending June 30, 1898, $763,300. From June 30, 1896, there has een expended, including outstanding liabilities, $998,171.71, and by the nd of the fiscal year the expenditures will average nearly $600,000 for ach fiscal year.

Q. During that time how much has been set aside each year for levee work, approximately?—A. My remembrance is (for the two years 1896 and 1897) about two millions and a half.

Q. Part of that amount for dredges and dredging was used in purchasing dredges, was it not?—A. Part of it. Four dredges have been purchased and entirely paid for.

Q. Is that included in the $600,000 a year that you said was set aside for dredging purposes?—A. I intended to include the cost of the plant constructed up to date.

Q. You have given us the amount that has been allotted for the two years collectively for levee building, and you also stated the amount that had been allotted each year for dredging purposes; now, in that allotment for dredging purposes you also included the cost of the plant?—A. Yes.

Q. Leaving out the cost of the plant and facilities, how much was assigned each year for dredging purposes?—A. The estimate of the committee on dredges is some $360,000 a year for operation for the entire plant.

Q. For the entire dredging plant?—A. Of course we have had less than half of that dredging plant, so the amount would be less than that.

Q. As a matter of fact, then, in 1896 and 1897 you have expended less ıan $300,000 each year in dredging, outside of the cost of the plant?—A. Yes; less than $200,000.

Q. Will you please state what the dredging plant consists of; when it ras acquired, etc.?—A. The first boat acquired was known originally as he experimental dredge, and was afterwards called the *Alpha*.

Q. What did that cost?—A. The boat itself, as it stands at present, supposed to have cost somewhere in the neighborhood of $80,000; ıat is, for the bare dredge and plant immediately connected with it, ıt the tenders or anything of that kind.

Q. Now, the next boat?—A. The next boat purchased was the *Beta*. ıe *Beta* was purchased under a contract providing that 50 per cent the contract price extra should be allowed the contractor as a ınus in case he exceeded the specified capacity of 1,600 yards an hour r 50 per cent. His bid was $172,775, and he got the bonus, making 86,387.50 more.

Q. That would make the cost of that dredge about $258,000.—A. ot exactly, because he didn't comply with the specifications in other ırticulars.

Q. And was docked?—A. He was docked $40,380.25; making the ıst on the final settlement a little less than $219,000.

Q. Well, now, the next boat. You have two more, haven't you?—A. es, sir. The next boat purchased was the *Gamma*, which cost practi-ılly $85,000. The next was the *Delta*, which cost practically $125,000.

Q. That makes four?—A. That makes four. Those are all that have een paid for. There are two more nearly completed, the contract pro-iding that no payment shall be made on them until they have been ımpleted and tested.

Q. What is the contract price to be paid for each of them?—A. $208,000 for the two.

Q. In addition to these dredges, what tenders and other facilities accompany them, belonging to the dredging plant?—A. There has been very little of that constructed. What little I have on hand has been transferred from other districts. That plant practically remains to be entirely constructed, and I have the money already allotted for that purpose in my hands for the construction of a plant the present year. I also have the money for one additional dredge and plant.

Q. Outside of these six?—A. Outside of these six.

Q. That will give you seven dredges in all?—A. Seven.

Q. As I understand it, this big dredge, that cost so much and was built under contract, has not proven a success?—A. She draws 7 feet of water, and the difficulty is that if we get her down to a place where there is only 6 feet we can't get her over the bar.

Q. Can't work her?—A. She just goes down and looks at it; that is about all. We tried this year to force her right down through, head on, and got her badly aground, strained her throughout—like to have pulled her in two before we got through with her.

Mr. GALLINGER. Who is responsible for the building of a dredge boat costing over $200,000, drawing more water than there is in the stream?

The WITNESS. I don't know. There is this to be said about it, however, that the inspectors never discovered the mistake until the machinery was delivered on board. The contractor succeeded in deceiving them as to the weights. The contract was let, as those contracts always have to be, with the machinery scattered all over the country, and when the machinery was actually delivered on board it weighed a good deal more than what they expected, and what the contractor had promised.

Q. Was that contract forced upon the commission by direct legislative action of Congress, or was it a contract that the commission made of their own motion?—A. I wasn't here at the time, so I know nothing about that. I think probably Colonel Flad would know more about that than I do.

Mr. GALLINGER. Captain, what was this bonus paid for?

The WITNESS. For increased pumping capacity. The contract required the dredge to pump 1,600 cubic yards of sand per hour, measured in a barge, and a bonus was allowed up to 50 per cent for any increase up to 50 per cent in the contract capacity. The most the contractor could earn was $259,162.50, for which he was obliged to deliver a dredge which would pump at least 2,400 cubic yards of sand per hour.

Mr. NELSON. Major Handbury, how was the contract made, on the part of the Government, for this dredge we have been talking about; by the Mississippi River Commission?

Major HANDBURY. By the Mississippi River Commission.

Mr. NELSON. Did they do it of their own motion, or was it under special legislative direction of some kind?

Major HANDBURY. If I may be permitted, I can give a brief history of that matter as I gathered it from the records before I became a member of the commission and from my knowledge of it since I became a member. At the inception of this dredging business the commission was without experience in anything of this line. There were a number of men scattered throughout the country, dredge builders, who had had a good deal of experience in different localities in building and operating dredges. With a view to getting at that experience the commis-

dvertised for bids. I believe at first they advertised for plans
pecifications for a dredge suitable for this work, and these men
tted their plans and specifications, and I believe there was a
l offered for the plan which should be accepted. Mr. Bates had
good deal of experience in this matter, and he submitted a plan
commission, which was accepted by the dredging committee and
ved by the commission afterwards, and a contract was entered
nder his plan for the construction of this dredge under his plans
pecifications. Amongst other specifications in that contract was
rovision that this dredge was to draw only 4½ feet of water, and
to do certain things—it was to deliver through 1,000 feet of
,600 cubic feet of sand per hour, and if it delivered more than
er hour Mr. Bates was to be paid a proportional amount up to 50
nt of the total contract price.

That is where the bonus came in?—A. Yes. Now, Mr. Bates went
k and apparently devoted his time and attention to getting up a
and machinery that would deliver 2,400 yards per hour through
000 feet of pipe, and apparently lost sight of other points in the
cations, such as that the dredge was to draw only 4½ feet of water,
hen it was launched and delivered for acceptance it was found
t would draw 6½ or 7 feet. The commission wanted the dredge
adly, and besides that defect in it there were a number of others,
he was supposed to have remedied. On the test it was found
e could deliver 2,400 yards per hour, as the specifications pro-
so that under the rules given for testing he really earned that
so the commission was in favor of giving him credit for his
al contract price, plus the bonus, and deducting from that amount
ount it would cost to lighten the boat. There is where the $40,000
tion came in. So the Government is not really paying $259,000
e dredge, drawing 7 feet (as it does now), but it is paying that
t for the dredge drawing 4½ feet. There is supposed to be enough
ack from his contract money to pay for lightening it.

NELSON. Well, he got a bonus of over $80,000 and was allowed
ction of $40,000, so the net amount he got was over $40,000?

Mr HANDBURY. He got his bonus, of course. Then he was charged
day for a certain number of days (I have forgotten the exact
r) for nondelivery on time. That is, in brief, a history of the
.

NELSON. Has anything been done to lighten it and make it draw
ater?

Mr HANDBURY. The decision was not rendered from Washington
ate last year, and we didn't have time to advertise for bids and
e boat lightened before this season's work had commenced, so the
ng committee recommended that we take the dredge and do the
e could with her drawing 7 feet, and next year, after this season's
s over, go to work and lighten her. Plans and specifications are
prepared now by Captain Waterman, in his office, for bringing
out, and when she is finally finished, so as to draw 4½ feet, she
much more serviceable than she is now.

GALLINGER. Are you satisfied, Major, that she can be lightened
o draw but 4½ feet of water and retain the pumping capacity she
as?

Mr HANDBURY. Oh, yes; she can be lightened. That won't detract
m her pumping capacity. There are a number of things about
edge that are defective and will have to be changed—matters
il—such as changing the cutters, changing the nozzles, and things

of that kind, such as we found detract very much from the efficiency of the dredge and add a great deal to the cost of the dredge; but that is one of those things which the Government officers went into at first, you see, for lack of experience in this particular line. It was a trial. They went from the *Alpha*, which was a dredge of comparatively small capacity, to one considered to be as large as anything they would want—went to the further extreme. Now, then, these other dredges that we are making are intermediate. We are taking advantage of our own experience, and in my judgment——

Mr. NELSON. You are building them yourselves?

Major HANDBURY. Yes, sir; from plans and specifications drawn up by ourselves. And we think we are getting a better class of dredges, and that we will be able to do much more efficient work with them at a much less cost.

Mr. GALLINGER. Can you imagine a private individual or corporation accepting a piece of work as defective as this was, under any circumstances, and paying for it?

Major HANDBURY. I can imagine they would accept it under the conditions of the contract that was made. These people earned their bonus. The dredge will deliver 2,400 cubic yards an hour.

Mr. GALLINGER. Did they, as a matter of fact, earn anything, when they didn't comply with the stipulations of the contract?

Major HANDBURY. They did not. The dredge really ought not to have been accepted until they had fully complied with the contract. But here was the situation of affairs: The river people were clamoring for these dredges and for an open channel, and the Government accepted this dredge only, you might say, with a string to it. Mr. Bates the whole of last year had a string to that dredge. He could have taken it back. It was understood that he was going to take it back and lighten the dredge. But now he has been allowed to turn it over, and the Government has got a clear title to the dredge; but in lieu of his making it lighter, diminishing the draft to 4½ feet, the Government has deducted an estimated amount for that purpose. That is the way the thing stands.

The examination of Captain Waterman was then resumed, as follows:

Examined by Mr. NELSON:

Q. Please state in a general way the amount of dredging you have done each year, where you have dredged, and the extent of the dredging.—A. During the last low water before this two dredges were available.

Q. That is, in 1896?—A. In 1896, the *Beta* and *Alpha*. The *Beta* covered the territory from Memphis (which is 230 miles below Cairo) to Point Pleasant, which is 79 miles below Cairo—a distance of about 150 miles.

Q. That dredge dredged up and down at different places?—A. Yes, sir. It really made one trip through from Memphis up to that 150-mile point, dredging at all crossings where shoal water was developed. The *Alpha* covered the remaining 80 miles up to Cairo.

Q. So that the dredging that season was all above Memphis?—A. All above Memphis. That year was phenomenally a high water year, so there was no difficulty in those dredges maintaining good navigable water over that stretch of territory.

Q. What has been your experience in dredging? For instance, when you have dredged out a channel, how long, as a general thing, would it remain in that condition?—A. So far as my experience goes, that

ls on where the channel is selected. If the channel is selected the river is going in low water, it is all right, it will last through r water season. But you have got to go where the river is going; attempt any forcing process you are going to lose all you have . It requires the most careful study and the most careful sur- It requires not merely the experience of an engineer, but the ence of a pilot. It is a class of work where the experience of a ı judging where the river is going to is of vast importance. The ouble with a pilot running the entire thing is the fact that a an't understand a map; it is beyond him. We have tried to ı maps to pilots, but it didn't matter whether the water was on p or not, they never would believe it unless they could see it. ır experience goes to show that if the right channel is selected, the river is going in low water, in the lowest stage, that the ill maintain itself and in many cases deepen itself.

lo the most important factor in connection with dredging is to ıt you locate your work in the proper spot? You want to select ıl low-water channel of the river?—A. Yes, sir.

ınd if you do the river will be scouring and supplementing the f the dredge?—A. During low water. But if a rise occurs in ver meantime that upsets your calculations. There will be r change. Therefore, the most unfavorable state of affairs for ıency is to have a succession of rises; but when such a state of occurs, as did last year, the river needs but little dredging any- ecause they have got the water.

Tou mean last summer—1897?—A. No; 1896.

Did you do any dredging last summer?—A. Yes, we did quite a eal.

Vhere?—A. Oh, you mean this present summer?

Tes, 1897.—A. Now this year is an extreme low-water year——

ince the flood?—A. Yes, sir. And I have had four dredges in ld. Practically, though, for one month the *Alpha* was entirely on account of four yellow fever cases aboard, and the quaran- ficer took possession of her at Cairo and prevented her going out e field. The quarantine was only lifted the 1st of October.

Vhere have you conducted your dredging this season?—A. From o a short distance below Memphis.

Covering the same reach, practically, that you did the year ?—A. The same reach. In such a year as this it undoubtedly ıt least three large dredges between Cairo and Memphis to keep ınnel open. Probably with the two additional ones that are now ıg we can keep it open down as far as Helena, a hundred miles ; but then you have got from Helena to Vicksburg (which is d by the commission's project), 300 miles. It will need at least nore.

Tou have done no dredging below there?—A. Not below Helena ksburg. We have no dredges to spare, and furthermore the ssion's project really doesn't extend beyond Vicksburg. But of the shoalest water I have had reported this year is below urg. There is only 6 feet down there.

ıt what places?—A. That is Newtown Bend; it is below Vicks- Then at Fords Crossing, below Natchez, there has been reported That has heretofore been a very shoal crossing, but has been l condition this year. At the mouth of the Red River, below az, there has only been reported 7 feet.

For keeping open a good navigable low-water channel the only

active work you are doing at present on the river is this dredging, isn't it?—A. That is all we are doing at present.

Q. To keep up an efficient navigable low-water channel?—A. Yes, sir.

Q. With reference to maintaining a low-water channel in the river, the levees can cut no particular figure, can they?—A. I don't see how the levees can cut any figure at low-water stage at all.

Q. At such times navigable channels must be secured by dredging and dike work and revetment work and riprapping, mustn't they?—A. Yes, sir. The general theory of revetment, as I understand it (bank protection), is simply that if the river can be held in one particular place so it will go from high water right down to low water in the low-water bed, be held in that position for a series of years, that it will improve itself.

Q. Scour a channel?—A. Yes, sir. And what is still more important, local caving will be prevented, thus preventing deposits in the channels.

Q. And that is why on one side you build out a dike (or what we call a wing dam on the Upper Mississippi) on one side, and on the opposite side, if it is necessary, you put in your revetment?—A. No, sir; the wing dams are generally for a low stage; they are not intended to work at high stages at all.

Q. No; but I mean it is applying the same principle.—A. Yes, sir.

Q. A dike and a wing dam are built on the same principle—that is, to catch the floating sediment in the river and have a bar form?—A. Yes, sir.

Q. You are familiar with the floods that occurred in the river last spring?—A. Yes, sir.

Q. In your opinion, from what sources did those floods come and what caused the breaks in the levees?—A. I understood you to say (I haven't read it very carefully) that Mr. Starling claimed that the amount of water carried down during the last flood, during the dangerous stage, was much less than had been known previously. Well, I don't agree with him on that point.

Q. No, I don't think he says that; he doesn't say "much less."—A. I think the estimates of the amount of water that passed down during the previous great flood of 1882 were, after all, made in the roughest kind of a way.

Q. The chief flood this last spring came from the Ohio, didn't it, in the first instance?—A. Yes, sir; the main floods always come out of the Ohio River.

Q. Out of the Ohio and its chief tributaries, the Cumberland and the Tennessee?—A. Yes, sir.

Q. And the Ohio, as I understand it, this year was unusually high and continued at a high stage because the floods of the Tennessee and Cumberland and of the Upper Ohio took place at the same time?—A. Yes, sir.

Q. Which is not always the case.—A. No, sir. Well, it was reenforced by water out of the Mississippi, too.

Q. Yes; but I am referring to the Ohio.—A. Yes, sir.

Q. And, as I understand it, the flood of the Mississippi above Cairo, and of the Missouri above its mouth, this year were rather less than they have been at other flood stages.—A. On the tributaries of the Mississippi?

Q. Yes; I mean that above Cairo the Mississippi itself, from Cairo up to the mouth of the Missouri, and the Missouri above its mouth, and the Mississippi above the mouth of the Missouri—that at those three

ıe flood was not as great this year as it has been in prior floods.—
gauge readings were lower; yes, sir.
s; lower at high water.—A. But I don't think the gauge reading
l test of the amount of water passing.
ıu don't think, then, that these gauge readings that we have in
r are a test of the force and course of the floods?—A. Not an
ı test of the amount of water that goes down. The gauge
ı measure, of course, the danger from overflow. But with a
iver and a falling river, at the same gauge reading (that is,
ıe river reaches a certain gauge reading when it is rising and
reaches the same gauge reading when it is falling) you will get
less discharge on the falling river at the same gauge-reading
the rising river. On the other hand, if the river rises more
ıt one point one time than it does another, the maximum rise
en gauge reading will always give you the maximum discharge.
:e the rapidity of the rise, I think, is a thing that cuts a figure
ı amount of water that passes down.
ıw rapidly it goes?—A. Yes, sir.
ptain, what was the distinguishing feature of the flood last
In what respect did it materially distinguish itself from prior
-A. I think the most prominent feature about it was its pro-
continuance at or near a maximum stage over the entire river
ıiro to New Orleans. For a period of ten days, or nearly two
ıomething of that kind, it was at the maximum point almost
le length of the river.
e had higher gauges before, in previous floods?—A. Yes; for
00 miles or so below Cairo, but below that the last flood sur-
ıny on record in gauge heights.
.t we had never had floods of such long duration before?—A.
f such long duration at or near the maximum stage.
your opinion, how was that excessive duration brought about?—
pose the confining of the river had something to do with it (how
'e it is hard to say), and also——
your opinion, then, the confining of the river, cutting off basins
iver by means of levees, had something to do with the height
ood?—A. Had something to do with the holding of it at that
e height. But there were practically two flood waves in the
Ohio and its tributaries, one following the other, and that
:edly had largely to do with it.
ere were two floods in the Ohio, and an intervening flood of the
ppi came in, didn't it?—A. Yes, sir; there were two pronounced
Cincinnati, and in the Cumberland and Tennessee. Only one
ıve, however, was observed on the Cairo gauge.

xamined by Mr. BERRY:

ınderstood you to say, Captain, that the confining of the water
ething to do with the long-continued high water, in your opin-
. I think so.
ıd your opinion is that the high water was attributable to the
:t more water went down at once in 1897 than in 1882?—A.
idence as we have indicates that there was about the same
at or near the maximum stage.
ıu think there was about the same amount of water?—A. I
ere was about the same number of cubic feet per second at or
ı maximum stage. At Warrenton, where we get the full river,
harge last spring was 1,750,000 cubic feet, which is practically

the only discharge we got at the top gauge reading. The maximum discharge in 1882 is given, I think, as 2,000,000 cubic feet, but that was arrived at in the roughest kind of a way.

Q. Did the gauge show higher water at New Orleans in 1897 than in 1882?—A. Yes. There was one other unusual feature about the last flood, and that is that the Red River remained low during the entire flood. It is possible that if the Red River had come up, as it frequently does, at the critical moment, the floods below the mouth of the Red River would have been far worse than they were.

Q. As a matter of fact there wasn't but one crevasse, or two, below, was there?—A. No; the Red River seemed to act as a safety valve on that occasion. But the trouble is that the Red River doesn't always act so. Sometimes it rises and throws the water the other way.

Mr. GALLINGER. Captain, in answer to a question propounded by Senator Berry you suggested that the discharge per second was no greater in 1897 than in 1882. If the flood of 1897 continued much longer at its high stage than that of 1882, was there not a much larger aggregate of water discharged in the latter flood than in the former flood?—A. I believe that there was more water went down during the most dangerous period in 1897 than in 1882. The accompanying Exhibit A shows the gauge hydrographs at Cairo for 1882 and 1897. An examination of the curve for 1897 shows no evidence of two distinct rises; it is all one. It will be observed that the gauge stood above 48 feet twice as long in 1897 as in 1882, but these conditions are reversed if we go down to 30 feet. Taking the total amount of water passing from low water to low water, I think 1882 broke the record; but considering only the extreme stages I think 1897 was ahead.

Q. Do you think that the improvements, in other words the levees, did have something to do in making the water level higher than it would have been without them? Do you wish to be understood as so stating?—A. The statement I made, I think, was that the narrowing of the channel tended, to a certain extent, to prolong the flood; that is, that the leveeing, all the way down the river, probably narrowed the outlet so as to furnish less room for the outflow of water from above than there would have been without that narrowing, and that it therefore tended to prolong the flood. The other point, whether the cutting out of the basin tends to raise the level of the flood plane, is another matter. I don't know much about that myself; it seems to me reasonable, though, to believe that it does.

Q. What do you think as to whether it tends to lower or to raise the bed of the river?—A. I don't think there is any evidence of that fact at all. We made very careful investigations on that matter and have taken innumerable soundings in order to find that out.

Mr. GALLINGER. And there is no evidence in either direction?

A. There is evidence that in certain places it has lowered, and in other places there is evidence of a slight rise; but taking the thing on the whole, there is evidence of things being about the same as they were before—that is, through the best leveed section of the river, the lower portion.

Q. There is no appreciable difference?—A. Well, there is an appreciable difference at different places, but, taking the thing as a whole, on an average the effect seems to be slight. I think that as a whole it cuts out, if anything, a little deeper.

Q. Its effect is rather to deepen than to raise the bed?—A. I think so, but very slightly. We have hardly had time to find out, in the short time the matter has been under investigation, whether it may not be due entirely to other causes than that.

Q. I would like to ask you, Captain, in regard to whether or not you believe that at a reasonable cost, and at what cost, if you believe it can be done at all, that river can be confined within levees at flood tide; not inside of its banks, but inside of the levees?—A. I don't know anything about it, except from the estimates of the commission, and I see no reason to believe that it couldn't be done for their estimates.

Q. You think it could be done, probably, within the estimate made by the commission?—A. Yes.

Mr. GALLINGER. What was the amount of the estimate, Captain?

A. Something over $18,000,000, I believe. They will always have to make a high-water fight, though. Of course, people can't simply put the levees in and then not attempt to do anything afterwards without expecting to have breaks in them; they will always have a fight.

Q. Do you or do you not think that the closing of the St. Francis basin would make it more difficult to hold the levees below, in the present condition of the levees?—A. I think that, generally, any reduction of the reservoir area tends to make it worse for the portions below. I don't know particularly about the St. Francis, but I should think it ought to come under the general rule.

Q. You think, then, as a general rule, that the levees ought to be made as perfect as they can be made below before the basins are all closed above. Is that the idea, that in building these levees it should be done from below and not from above?—A. Yes, sir; I think so.

Q. You think that the final perfection of the levees, before the final closing takes place, should proceed from below?—A. Yes, sir. I don't think the Louisiana levees needed to be as high before the basins were closed above Louisiana as they do now.

Q. But you think it can all be confined within levees at an approximate cost of eighteen or twenty millions of dollars?—A. Yes, sir; I think so.

Q. Do you think it possible, if the water that went into the St. Francis basin in the first rise of the river had come out at the mouth of the St. Francis at or near the same time that the second rise that went down the Mississippi reached that point, that below that point, at Helena, the water would have been higher than if the St. Francis basin had been closed?—A. I could merely give an opinion on that. I don't know that it is of any value whatever. The problem here presented is, supposing that two distinct separate rises had occurred at Cairo, which, as shown above, was not the case, and supposing a certain amount of water be diverted from the first rise and dumped on the second, would conditions below be worse than if no such diversion took place. As the first rise undoubtedly travels down the river most rapidly and can carry off the extra water most easily, I would say, if the above extraordinary conditions should occur, the effect of dumping this water on the second rise would be the most serious. I do not believe such was the case this year, and, furthermore, crevasse water running into the St. Francis basin could hardly be dumped at will on the second rise. Some of it would certainly be too late even if part of it got around in time to catch the assumed second rise. It is my opinion in the present case, however, that if no crevasses had occurred in the St. Francis basin the water at Helena would have been slightly higher than was observed, but I do not think very much higher. This is only an opinion, however.

Q. Do you think that any outlets from Cairo down to the jetties could be constructed at any reasonable cost by which the flood would

be decreased in volume either above or below the outlet; and if so what point could such an oulet be made?—A. I don't think it could done at any reasonable cost.

Q. Do you think any outlet could be made at Lake Borgne or the other lakes that would affect the floods as far up as Vicksburg Helena in any way whatever?—A. No, sir.

Q. Or decrease the amount of water?—A. No, sir.

Q. You don't think any outlet from the St. Francis basin down the jetties of the Mississippi River could be made, within any reasonal cost, that would improve the river below the basin?—A. No, sir.

Q. In other words, you think the outlet system is an impossibility? A. I believe in maintaining the outlet of the Red River.

Q. The channel?—A. Yes, sir.

Q. But I mean constructing them so as to prevent the overflo above; you don't think it is practicable in any way at all?—A. No, si I do not.

Examined by Mr. NELSON.

Q. It would be dangerous in the extreme, wouldn't it, for the low river, to allow the Atchafalaya to be closed; and even the Placqu mine and the Lafourche help a little?—A. Yes, and there is a larg commerce through the Atchafalaya. The Placquemine and Lafourc bayous are, however, entirely cut off by levees.

Q. Yes; on the Red River and on the Atchafalaya, and on the Gran River, and on those lakes in there.—A. Yes, sir.

Q. Do you not think, Captain, that it would be imprudent to entirel close by levees the St. Francis River basin before fortifying the leve below beyond what they were last spring?—A. In my own opinion would be.

The WITNESS. One thing that has impeded the dredging business ha been the yellow fever. It is impossible to receive supplies at Memph now. And of course, if any of our boats have connection with a qua antined town, all other towns refuse to have anything to do with th boats. And the men desert, you know.

(Witness supplemented his testimony by attaching Exhibit M, whic here follows.)

HENRY FLAD, sworn, testified as follows:

Examined by Mr. NELSON:

Q. Colonel, are you a member of the Mississippi River Commission? A. I am.

Q. How long have you been on that commission?—A. Since 1890.

Q. You belong to the Regular Army?—A. No; I was colonel of regiment during the war.

Q. And on the commission you are one of the civilian members?- A. Yes, sir.

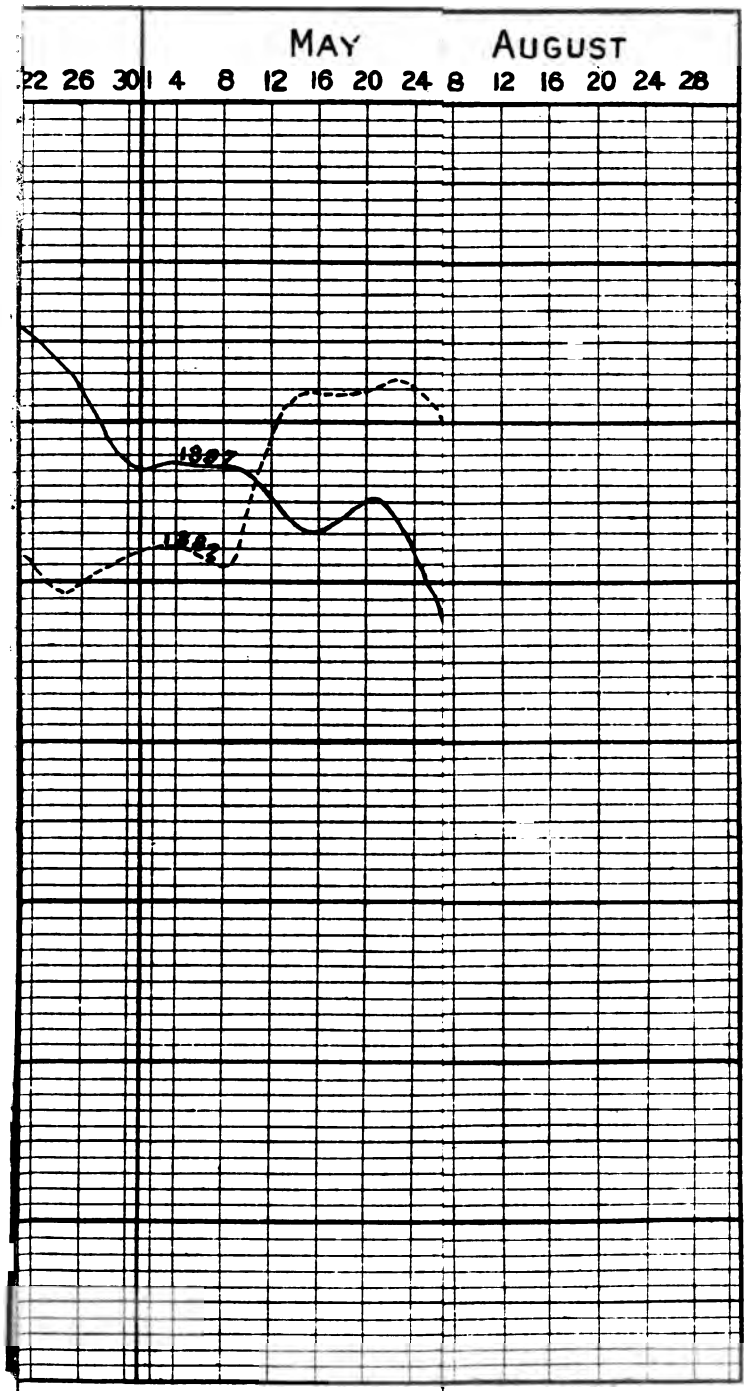
Q. You are a civil engineer by profession?—A. I am.

Q. How long have you been on the commission?—A. Since 1890.

Q. You are familiar with the recent flood on the Mississippi River? A. Yes.

Q. What, in your opinion, were the chief causes of the flood la spring?—A. We had too much water, too much rainfall.

Q. In what respects, if any, did the flood last spring differ from pri floods?—A. Mainly in the long duration of the rains. When there we no rains in one place and the water went down a little there, it wou rise in another place; it was a continuous rainfall.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Q. The flood wasn't quite so high last spring as it had been during prior floods, was it—that is, it didn't attain quite the elevation it has in former floods?—A. At some places it did.

Q. How was it at Cairo?—A. At Cairo I think it was about as high as it ever was before.

Q. Well, on the Mississippi River from here up it wasn't?—A. No.

Q. Nor in the Missouri?—A. No.

Q. Nor in the Upper Mississippi?—A. No.

Q. The chief flood came from the Ohio?—A. Yes; from the Ohio, Cumberland, and Tennessee.

Q. In your opinion can anything be done by way of building reservoirs anywhere to check, limit, or restrain the floods of the Mississippi River?—A. I don't think it would be possible to do any good.

Q. Not on any of these streams?—A. Not on any of these streams.

Q. What method do you regard as the proper method to check and restrain the overflows and floods?—A. Simply to make perfect the levees; to make them higher and stronger.

Q. You think the defects in the levees, as demonstrated by the last flood, are that they were not high enough and not strong enough?—A. Exactly. In Louisiana they stood first rate. It was only where they were too low. In the long flood the levees got weak in some places, and some old works were in there that were not built right.

Q. Those levees in Louisiana are mostly old State levees, are they not?—A. I suppose about half were built by Louisiana and half by the United States; perhaps more by Louisiana than by the States.

Q. One thing that helped them there was that the Red River was not at a flood stage?—A. The Red River wasn't very high.

Q. You can think, then, colonel, of no other remedy for the floods except building stronger and better levees?—A. That is my opinion.

Q. What is your opinion of the outlet system?—A. I think that is no good at all.

Q. It couldn't be of any advantage, at all events, above the mouth of the Red River, could it?—A. No.

Q. It wouldn't be a practical question to build outlets above the mouth of the Red River at any reasonable cost, would it?—A. There is a natural outlet—the Atchafalaya—of course. That would prove that outlets might be made, but it would be——

Q. Well, there are no obsolete natural outlets above that point, are there?—A. No.

Q. (To Major Handbury.) Do you know of any, Major?

Major HANDBURY. No, I don't think of any.

Q. So below the mouth of the Red River (for instance, at the Atchafalaya, Plaquemine, La Fourche, or Manchac, or those other obsolete bayous that connect the Mississippi River with Lakes Maurepas and Pontchartrain), even if it was possible to make outlets, they could only affect and operate on the river below Vicksburg, and could not, in the nature of the case, affect the floods above there. Isn't that true?—A. I think that is so.

Examined by Mr. BERRY:

Q. Do you think the levees can be built high enough and strong enough so the water of the Mississippi River can be kept within them?—A. I have no doubt. It can be done. Of course it will cost a good deal of money, but I have no doubt it can be done and certainly will be done.

Q. Do you think it can be done at a cost of approximately eighteen or twenty millions of dollars?—A. Yes.

Q. From Cairo to the jetties?—A. Well, now, of course there might be a time when the rivers would rise all at the same time, you know, and you could hardly build a levee that would stand under all circumstances.

Q. But, judging the river by the past, you think it can practically be confined within the levees at a cost of about eighteen or twenty millions of dollars?—A. Yes, sir.

Q. But you don't think that can be aided by any system of reservoirs on the upper river?—A. Not at all.

Q. And you don't think that the outlet system, beyond what it is now, would have any practical bearing on the matter?—A. The Lake Borgne outlet would not do any good.

Q. You don't think the Lake Borgne proposition would do any good at all?—A. No. Perhaps for a little time it would help, but it would silt up.

Q. And that wouldn't help the floods up above—at Helena or Arkansas City—wouldn't do any good in that section?—A. No; none at all.

Q. Were you educated as an engineer in this country or in a foreign country?—A. In Germany.

Q. You were a civil engineer there?—A. Yes. I came over from Germany in 1849.

Q. And your profession was civil engineering?—A. I was on river work there for a year or two. I was on the improvement of the river Rhine.

Mr. NELSON. On the Lower Rhine?

The WITNESS. On the French boundary.

Q. And your business has been civil engineering?—A. Yes.

Q. I believe you said you commanded a Louisiana regiment during the war?—A. Not a Louisiana regiment. I commanded one in Louisiana.

Q. You commanded a Union regiment in Louisiana?—A. No; I was at Atlanta and Vicksburg, and so on, with the Union Army.

Q. You were with Grant's army at Vicksburg?—A. Well, a short time; yes.

Examined by Mr. NELSON:

Q. What information can you give us about bank revetments and the cost of them and their utility?—A. I think bank revetments are very useful. Their cost has been rising rapidly to about $40 a foot.

Q. Are they not too expensive, then, to be resorted to?—A. No; I think if a little more would be expended it would be better; if a little more stone was used. You can't very well at a lower figure build good works that will stand the immense power of the Mississippi River, and the depth, you know—it takes a good deal of money. They have done their best, but at the start they built the works too light.

Q. Would you supplement the levee work with revetment work in the river?—A. Certainly.

Q. In connection with repressing and restraining the floods, you would supplement and aid the levee work by revetment work in the river along the natural banks?—A. I would, certainly.

Q. You would have that accompany the levee work?—A. Yes.

ST. PAUL, MINN., *November 15, 1897.*

EDWIN BELL, sworn, testified as follows:

Examined by Mr. NELSON:

Q. Captain Bell, where is your home?—A. St. Paul.

Q. How long have you lived here?—A. In Minnesota, since 1850.

Q. What business have you been engaged in?—A. For a number of years I was on the river all the time. My brother and I were in business, but I steamboated during the summer time and turned my attention to the store in the winter time.

Q. Did you do steamboating yourself?—A. I did. I was captain and pilot for a good many years.

Q. On the Mississippi?—A. On the Mississippi and the Minnesota. I ran frequently up to Minneapolis, to the old warehouse there.

Q. From what point down the river did you run?—A. For two years I was running from here to La Crosse.

Q. Do you remember what time that was?—A. I don't remember exactly. It was when the Milwaukee road was first opened to La Crosse.

Q. And after that where were you?—A. I was employed constantly eight or nine years running boats.

Q. About how many years in all were you steamboating on the Mississippi?—A. I couldn't tell you exactly. I was under General Warren, on river improvements, for about five years.

Q. That was after you quit steamboating, wasn't it?—A. Yes, sir.

Q. About how many years, as near as you can tell, were you steamboating?—A. Probably ten years.

Q. And that steamboating was confined to the Mississippi River above La Crosse?—A. It was confined to the upper river. I have run to Galena, too. And I ran the first boat that ever was run on the Red River of the North; that was in 1859.

Q. During that time, then, you ran steamboats from Galena up?—A. Up to St. Paul.

Q. And some on the Minnesota River and some on the Red River of the North?—A. Yes, sir. I took goods to the Indians for I think two or three years, and I took goods to Camp Pope on that expedition.

Q. Then, after you quit steamboating you were engaged in Government works under General Warren?—A. Yes, sir; I had charge on the Minnesota River altogether between six and seven years, and on the Wisconsin River for one season.

Q. And you are familiar with those streams?—A. Yes, I am, as much so as a man can be that is on the river. And I understand currents about as well, I think, as can be.

Q. Are you familiar with the matter of floods on the Mississippi River?—A. Of course I am.

Q. And its tributaries?—A. I am; the Mississippi and the Minnesota.

Q. Are you acquainted with the reservoirs on the Upper Mississippi?—A. Only from what I have read and heard of them.

Q. Do you know anything about their effects on floods or on navigation?—A. I don't think they have but very little effect. I don't think they have any effect below Lake Pepin, and above that I don't think they have much. I think there were two years that boats didn't run in July and August, and this last year I think it was some time about the 10th of September that the boats got aground and had to be hauled off below Lake Pepin.

Q. Couldn't run up here?—A. Couldn't run up here.

Q. The last two years, you mean?—A. No, this last year.

Q. In your opinion can such reservoirs as those have any bene effects either on improving navigation or on the matter of che floods?—A. I don't see how they could check floods; and in rega the navigation the evaporation and soakage is so great that we get much benefit from the reservoirs. When we need water, b time it gets from the reservoirs down here the evaporation has be great that a great deal of the water is lost. On hot days in the mer time I have seen little currents wabble up onto a bar and the would rise up; that shows what evaporation there is.

Q. Now, what can be done here on the Upper Mississippi River tributaries that will have any bearing in reducing, checking, dimi ing, or restraining floods or overflows of the Mississippi River Just as I say in this paper:

My plan will move the sand or mud from the channel to the shore; also b islands. It will make long, deep pools. I claim 10 feet of water or more c made. The deep water will retard the current. The Minnesota River, for ins There is a strong current as far down as Carver, water 4 feet here. Here the cu begins to slacken. At Shakopee, 4 miles farther down, water 8 feet deep, curr less than at Carver. From Bloomington to the mouth of the river, about 12 the water averages from 10 to 12 feet deep; current here is less than at Shak After leaving the mouth of the river the current gets strong as above Carver, c to shoal water below. This shows the benefit of long, deep pools to retard s currents. The machine is so constructed that the current with the scraper w most of the work. The material moved from the channel is forced to the sho the strong current. The machine will make a cut from 4 to 6 feet wide, 20 long, 10 or more feet deep. The deep water and deep pools will solve the pr of the overflow of the Lower Mississippi River. There are many places on the where the water is deep enough. The machine moves down with the current the cut is made. To let boats and rafts pass by, the machine is moved in or o the endless chain and scrapers. Parallel mats are to keep the sand from g back in the channel again. Wing dams alone will not make deep water; the up the sand at their ends; it drifts down and forms a bar in the channel. The ernment dams can be utilized for this work.

Q. You believe, then, that the proper remedy for restraining floo the Mississippi River is this plan that you propose?—A. Yes, Deep water and long deep pools.

Q. You believe in deepening the channel of the river and cre pools?—A. Yes, sir; I do. That is my whole view.

Q. That is the remedy you would prescribe for relieving agains floods of the Mississippi River?—A. Yes, sir; that is the remedy.

Q. To deepen the river?—A. Deepen the river and make pools.

Q. By the plan you propose?—A. Yes, sir; that is my view. wing dams will never do it; that is my opinion.

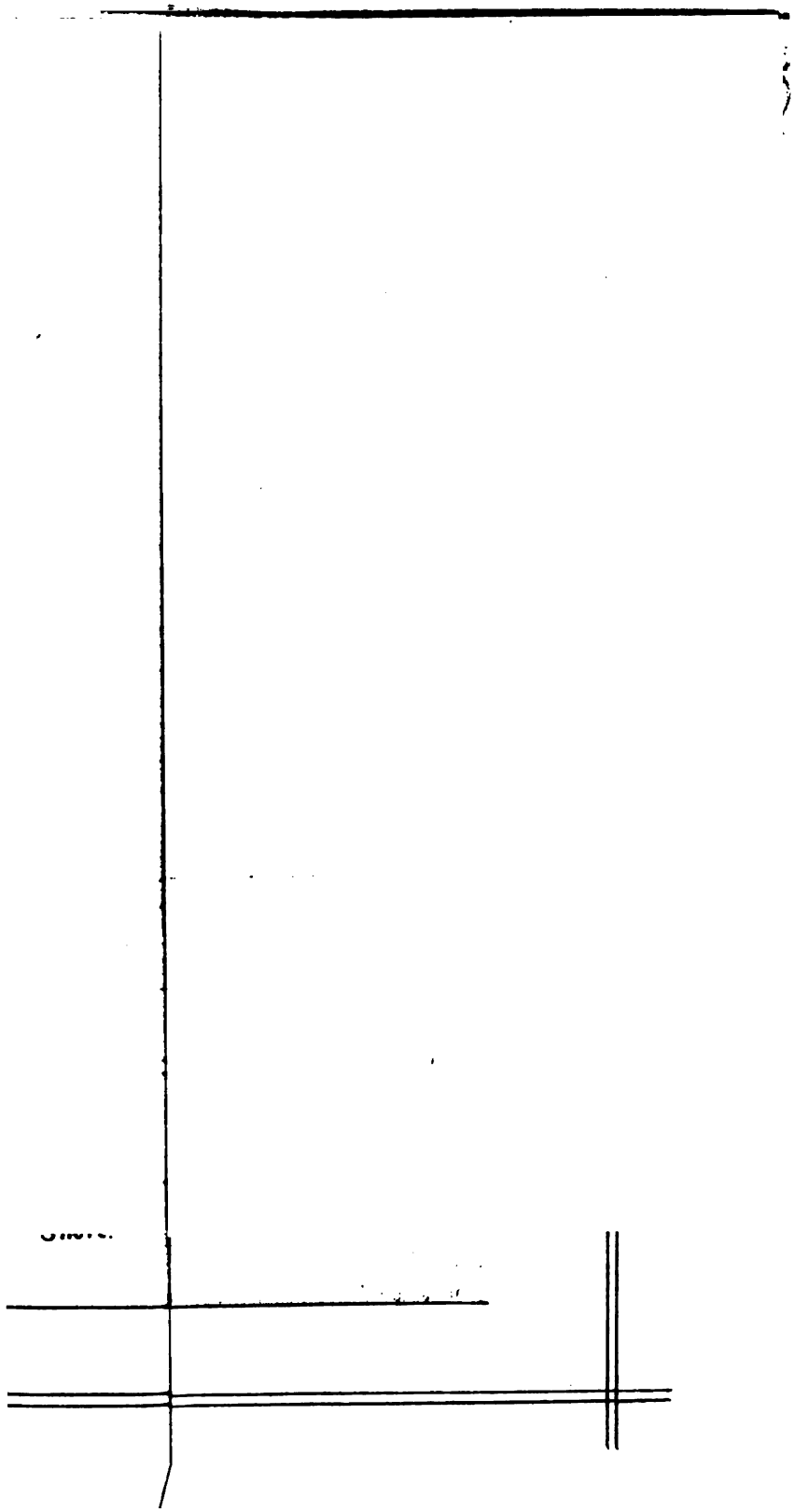
A. And your plan is as you have outlined?—A. Yes, sir.

Q. You have stated your plan is to deepen the river and make p in it. How would you deepen the river?—A. By the system illustr right here [producing a sketch and a model].

Q. You would deepen it by your plan as described in the dra you have here and in this model?—A. Yes, sir.

(The drawing was marked "Exhibit N," and follows here.)

Q. Can you tell briefly what your plan is?—A. A part of it I tried thoroughly on the Wisconsin River. My plan is to have scows, kept apart, with an endless chain with scrapers on to scrap the mud or sand at the bottom of the channel. There are slide bo on the upper scow that shoves down to within about a foot of the of the river, and the water rushing under will cut out the bar and the sand in toward the shore by the heavy current. Then I have a board the full length of the lower scow that shoves clear down int



ıd so the current can't pass under the slide board and must come out vard the shore. These slide boards running down into the sand also ıd to sustain the scow and keep her steady.

Q. Your plan, then, is substantially a species of dredging, isn't it?—Well, I do it more by the current; the current does most of the ırk.

Q. Well, you have those scows, and the endless chain you speak of is tween them?—A. Yes, sir.

Q. And the chain draws up the matter out of the channel, does it?—No, it doesn't draw it up; it scrapes the material at the bottom after is thrown up by the force of the water going under the slide boards the upper scow. If the water shouldn't go in fast enough under the de boards of the upper scow to scour it out the scrapers will scrape loose and the heavy current you will have then will bring it toward shore. It is like a dam in a river. You know what force there is a current if a dam breaks.

Q. Yes.—A. Well, it is on the same principle. I can go to work and up at the head of an island so the water will be thrown on the oppo- e side of the island and out of the reef away. I have done it on Wisconsin River. A bar had formed so that rafts couldn't get er it, and had to lay there, and a Government boat couldn't get by. ut a channel through so that Government boats and the rafts could through. There was a bar across the main channel, and by filling head of the island it threw the current around and cut out this ıf. I think there were five rafts lying in there that couldn't get er and the Government boat. The rafts went over the day after I set machine, and the second day, I think it was, after I commenced ırk the Government boat went over.

Q. Your machine, then, is a couple of scows with an opening between em, and you have a kind of endless chain like they have in an ele- tor or a mill for carrying up grain?—A. Yes, sir; only the chain ırks horizontally, it doesn't work upward.

Q. It works lengthwise?—A. Yes, sir.

Q. It is an endless chain with scrapers on.—A. Yes, sir.

Q. And you scrape the soil loose in the channel and expect the water do the rest?—A. Yes, sir; it will do the rest.

Q. Wash it off?—A. Wash it off.

Q. That is for deepening the channel?—A. For deepening the chan- l. By this system I take the material from the channel and deposit toward the shore. In the first place I put a wing dam in, and at the 'er end of the wing dam I put a light mat running parallel with the 'er, so as to keep the sand from getting back into the channel again. ıd when one cut is made, the machine drops down to make another t, and so on.

Q. You keep cutting into the channel?—A. Keep cutting the chan- l all the time.

Q. And the water is calculated to wash out the earth that you tear ?—A. Yes, sir. It must do so. And it guides it in such a way that can't go down stream; it must go toward the shore.

Q. You mean it goes to one side?—A. Yes, sir.

Q. How do you account for that?—A. Because it can't go below, it n't go under the slide board of my lower scow.

Q. You say the slide board at the lower scow stops the water?—Stops the water. It can't get under the slide board, and so the terial can't get down stream. It can't go under the scow at all; it st go toward the shore.

Q. Then at the downstream or lower end of the scows there is an opening between the upper and the lower scow, and the water runs through there and deposits the material that it takes from the channel over toward the shore and the water goes on down the stream?—A. Yes. The water can't go below the lower scow, because the slide board goes clear down into the bed of the river, and the water has to go between the scows.

Q. Then your theory is that the water must take the matter that you stir up with your endless chain and scrapers and wash it to one side or the other?—A. Only to one side, it can't wash it to the two sides. I place my scow at an angle of about 45 degrees, and if I want more currents in the river I put another scow at the end, independent of these two scows.

Q. Have you ever applied your system anywhere in the river here?—A. Nothing except the system shown in the model—a scow with slide boards. That is not the same system as shown on the sketch. The single system as shown in the model is not a permanent system of improvement, but the system shown in the sketch is a permanent improvement. I have applied the plan illustrated by this model on the Wisconsin River.

Q. But you never put the plan into practical operation as you would if you were going to do any extensive work?—A. No; I haven't been able to. Gen. G. K. Warren authorized me to build a system for turning currents. I built three sections of sixty feet each, and General Warren was removed and the machine was moved down to the lower part of the levee, and a watchman was put on and took care of that machine for two years. Colonel Macomb would never allow me to use it. It was finally spirited away.

Q. Have you ever presented your plan, as shown in the sketch, to the Government engineers here?—A. I have to General Wilson.

Q. You never got the Government engineers to adopt or recommend your plan?—A. No, sir; they never gave me any show at all. I will tell you what I did with this [referring to the model]. Major Houston sent for me to come over and put my machine to work in the Wisconsin River, when the work was first commenced over there of the improvement of the river by wing-dams; he wrote to me that he would have the scows all ready to put my machine on. When I went over I found the scows about done, and had carpenters go to work and make my slide boards; I put the slide boards in position, shoved them down to about one foot of the bed of the river, and formed a bar below the machine. I would raise the slide boards high up and that would drive the sand down into the slough; then I would shove the slide boards down again until I filled up the head of the slough. We cut away the reef on the opposite side of the island, and the rafts and Government boat went by.

Q. My understanding is that you have two scows with a machine between them?—A. Yes, sir.

Q. The scows are parallel?—A. Yes, sir.

Q. How far apart?—A. If you wanted a channel cut, say 6 feet, the scows would be about six feet and a half apart.

Q. Your machine, then, consists of two parallel scows placed in the river at a given angle, having a sort of endless chain or carrier with scrapers on, between them, to scrape the bottom of the river? A—Yes, sir.

Q. And loosening the material from the bottom and deflecting it under these scows?—A. Yes. The water rushes under the upper scow and carries the material through between the scows and forces it

ward the shore at the lower end of the scow. This distributing scow rces the material toward the shore. As the material from the chan- l is directed toward the shore by the distributing scow, the shore end the distributing scow is lowered down as far as required, and then e parallel mat is run along.

Q. Your theory is that when you get the silt or sand in the bottom the river torn up with your endless chain the water will carry it ong and your machine will throw it to one side instead of letting it n down the channel?—A. Yes, sir.

Q. How do you account for the fact that the silt that you have put motion will move to one side instead of moving down the current of e stream?—A. Because it can't get under the slide boards of the wer scow. The water carries the sand between the upper and the wer scow in the direction of the arrows on the sketch, and the dis- ibuting scow directs it toward the shore.

Q. Do you extend these scows out across the stream?—A. I put em at an angle of about 45 degrees with the stream, as shown on the etch. I can take in 200 feet or 250 feet, or 100 feet, by the addition more scows.

Q. Then it is because your scows are diagonal to the current that the ater and the earth is thrown toward the shore?—A. Yes, sir; the ater is turned toward the shore from the time it goes in between the ows.

Q. If you should put your scows parallel with the current or directly ross the current, it wouldn't do that?—A. No, sir.

Q. And your theory is that the water will carry the earth back ward the shore?—A. Yes, sir. And here is another thing. The ide boards of this lower scow are shoved down into the river bed so e water can't get under, and on the upper scow the slide boards are oved down to within 10 or 12 inches of the bed, and the water run- ng through there carries the material with it and forms a bar toward e shore. And then there is a standard at each end so you can gauge e depth of the water.

Q. To sum up, then, your system is substantially this: To put an paratus consisting of two long scows at a given distance apart and aced at a given angle (say an angle of 45 or 50 or 60 degrees) to the ain current, for the purpose of sheering the current, and then putting endless chain with scrapers on between the two scows, and having e chain with the scrapers scrape up the bed of the channel and get e sand and silt in motion and having the water carry it off to one le?—A. That is the idea, exactly.

Q. That is your whole system and plan?—A. Well, recollect this one portant part, that these slide boards on the upper side of the upper ow are shoved down to within a foot, say, of the bottom of the river, the water will rush under there and tear up the bottom.

Q. That is the scow on the channel side, as I would call it.—A. Yes, ; on the upper side.

Q. Well, on the inner side, or the channel side, your machine is put a given angle?—A. Yes, sir, at an angle to the channel.

Q. And the scow that is on the channel side is so fixed that the water n run under it and get into the space between the two scows?—A. es; the water will run in between the scows as indicated by the arrows the sketch, under the slide boards of the upper scow, and will run in the end as well.

Q. And you claim that this system will give us a deeper channel, and u also claim that it will tend to restrain and diminish the floods?—A. s, sir; that is what I claim. I claim that deeper water will decrease

the floods, the same as I have described on the Minnesota River. It will make slacker water, and it will hold the water in the river longer than it would be held without this system.

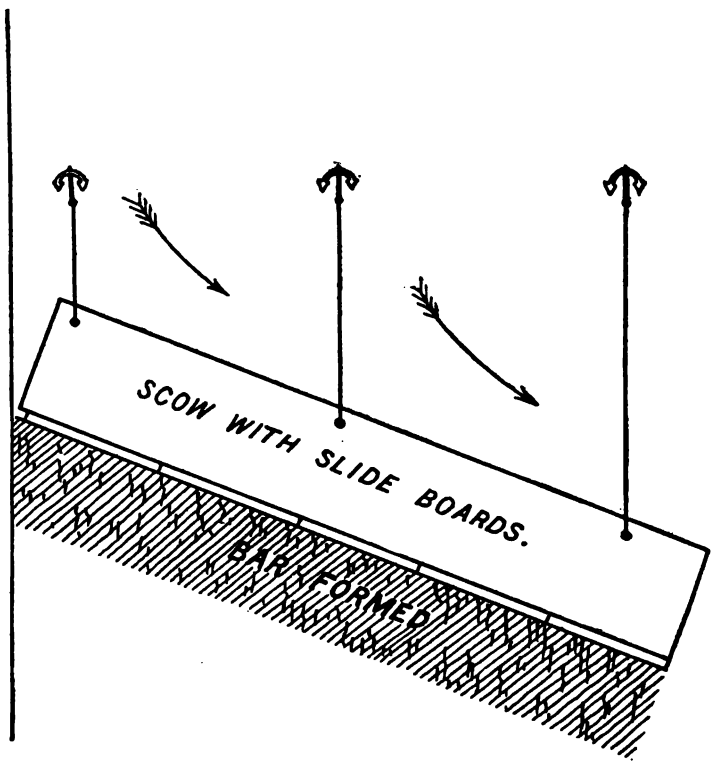
Q. Are you familiar with the matter of floods in the Lower Mississippi River below St. Louis and Cairo?—A. I was at Memphis at the time of one flood, but not as a steamboat man.

Q. Are you aware of the fact (which is a fact) that in the great flood of last spring, and also in previous floods, the largest quantity of water in the Lower Mississippi, below Cairo, came from the Ohio and not from the united Mississippi and Missouri? Of the water that passed down below Cairo last spring it was estimated that over 60 per cent came out of the Ohio and less than 40 per cent out of the united upper Mississippi and Missouri. Now, would you apply your system to the Ohio River, too?—A. I would, decidedly.

Q. What is your opinion of the levee system? Are you familiar with that?—A. Well, I have read a good deal about it. My idea is that along with the levee system they should have a machine to sheer the current from the bank, make a deeper channel, and (on the same principle as the scow with slide boards) turn the scow at such an angle that a bar will form below, and then elevate the bar onto the bank to raise the bank. There is no system in the world that will sheer a current nicer than the one shown in the annexed sketch, Exhibit O.

EXHIBIT O.

SCOW WITH SLIDE BOARDS TO SHEER THE CURRENT FROM THE BANK WHERE THERE IS DANGER OF A BREAK IN A LEVEE ON THE LOWER MISSISSIPPI RIVER.



Bar to be elevated to raise the bank to prevent a break through the levee.

Q. Your idea, then, is that the remedy for floods on the Lower Missis-
pi would be to deepen the bed of the stream?—A. Deepen the bed
the stream.
Q. Right along?—A. Right along.
Q. By means of your system or plan?—A. Yes. After Captain Eades
through the bill to build the jetties there was a bar formed between
jetties, and for about three weeks they couldn't move on account of
bar, and I sent him a plan of scows and slide boards, and they cut
ay the bar and he went on with his work. And I have letters from
ptain Eades thanking me.
Q. Captain Eades applied your system, then?—A. Not only that, but
took my plan for building these mats.
Q. Well, did he apply this system at the mouth of the jetties?—A.
applied it for cutting that bar away.
Q. Have you any letters of his showing that he used that?—A. No,
ave not; and I will tell you why I haven't. I had several letters
m Captain Eades in regard to the whole jetty system. I went down
see him, and was with him a day and a half. His secretary wanted
to send down my plans and specifications, and I wouldn't do it; I
nped aboard a boat and went down and saw him, and was a day and
ıalf with him before he ever started on the work.
Q. Well, did he to your knowledge, or did he admit to you, that he
l applied your system there?—A. No, sir, he didn't; only he thanked
for my many suggestions.
Q. That was all?—A. Yes.
Q. But you have no reason to think that he applied your system in
ual operation to any part of his jetty work?—A. I have no knowl-
ge of it, only I understand he used my plan for building his mats on.
Q. You don't think that large reservoirs to hold back the water during
ıes of flood, and let it out when the river got smaller, would be of
y effect in diminishing or restraining floods?—A. Not much. By the
ıe the water gets down, the evaporation, as I said before, is so great
ıt there is a great deal of water lost.
Q. What do you think of the levee system? Do you think it is proper
continue it, to build more extensive levees down South?—A. I cer-
nly think that is the only way to prevent overflows down there. I am
great believer in reservoirs.
Q. You believe, then, that the levees should be built better and
her?—A. Higher and stronger; that is my view.
Q. And you would supplement the levee work by your system of
dging out the river?—A. That is exactly what I would do; and put
material that is thrown out and forms a bar on to the levee as the
rk goes on.
Q. You mean the sand you take out by your machine you would put
top and apply it on the levee embankments?—A. Yes, sir. I have
ver been able to get but this one machine to work (on the Wisconsin
ver) because they wouldn't allow me to. They called my system a
nporary improvement. Now, this (the model) is a patent I got out
removing sand bars and turning currents. That is temporary. But
s (the sketch) is permanent.
Q. You claim, then, that your system is useful and calculated to
nove bars and obstructions in the channel and to divert the channel
the stream?—A. Yes, sir.
Q. As well as to deepen the channels?—A. As well as to deepen
m. And you can divert them; of course you can.

Q. What would you run this endless chain with; with steam on board the scows?—A. With steam, just as shown on my sketch; there is a platform there.

Q. And you would keep these machines going up and down the river, scouring the bed of the river?—A. I would, indeed. And I feel satisfied I could make 10 feet of water; that is, where there would be 4 feet I am pretty sure I could make 6 feet more.

Q. Now, they have been working on these wing dams and riprapping about eighteen years?—A. Yes.

Q. And you don't think that it is good at all?—A. I don't think a wing dam is going to make deep water. It makes deep water in the vicinity of the dam, but the water carries stuff along and it lodges below the dam. Captain Abbot, in his letter, explains my view exactly.

Q. You concur in the views expressed by Captain Abbot in that article [referring to a newspaper article produced by the witness]?—A. I do. That is my view exactly.

The article referred to is as follows:

RESERVOIRS ARE FULL—CAPTAIN ABBOT DISCUSSES THE RIVER IMPROVEMENTS.

Capt. F. V. Abbot, of the Engineer Corps, U. S. A., who succeeds Col. William A. Jones at the army building, said yesterday that he had not received any official notification of his appointment as engineer in charge of the Mississippi dam between St. Paul and Minneapolis. He knew nothing more about it than what he had seen in the newspapers. Asked about the condition of the reservoirs at the head waters of the river, he said that he had not been long enough at his present post to gain full information regarding the Government improvements.

"But," he added, "I can say this, that the reservoirs have never been so full at the same season of the year as they are now. That is the result, of course, of the surplus of water last spring. Yes, I did hear that the river steamers found the channel very shallow not far below St. Paul early in the month. Yet there was water enough, only it persisted in spreading out instead of remaining in the channel. That is a great fault of our Western rivers. But after a while the Government improvements will be of much additional value to navigation. There are only 5 reservoirs constructed now at the headquarters, and there are 41 reservoirs included in the complete Government scheme. When those additional reservoirs will be built will depend upon the appropriations made by Congress. Again, the system of wing dams on the river from Minneapolis south is as yet incomplete because of the same lack of appropriations. The usual method is to put a dam in at some point where the water is particularly shallow. The river then cuts out a channel just there, and relieves the difficulty. But unless the next dam is only a short distance below that dam, the river is sure to carry along some of the displaced soil and deposit it in the channel farther south before the next dam below can exert its influence. When the river has a wing dam at every necessary point from here south, the channel will be kept at a satisfactory depth, and when our 41 reservoirs are built we shall be able to increase the depth of the river for a very long distance below this point."

Q. What do you think of the jetty system as it has been applied to the mouth of the river? Do you think it has been a success?—A. I think it is the only way to improve the river there.

Q. Have you been down there to examine the jetty system?—A. No, sir.

Q. Are you aware that owing to the fact that there is no current in the Gulf at the mouth of the river that there is continually a bar forming from the silt and the sand and the material that is carried down the river, and that that is going on extensively owing to the fact that there is no current in the Gulf to carry off the matter?—A. Now, that is what Captain Eads and I had a great discussion about. I don't know whether you are aware or not of how those jetties are built. Do you understand how they are built?

Q. I do, in a general way. He put in a system of piling, didn't he?—A. Yes; sheet piling.

Q. And then in among the piling he put willow mattresses?—A. Yes, sir.

Q. And anchored them with rock, and the movable sand and silt went in and filled up between?—A. Filled in between the mattresses.

Q. That is about it?—A. Yes; that is about it.

Q. And the jetty principle is based on the idea of confining the channel of a stream within narrow limits and then have the water do its own scouring?—A. That is it. And there was another point we had a long talk about—in regard to running a sill through the Southwest Pass to compel the current to pass between the jetties.

Q. Yes. They put in a mattress sill both at the Southwest Pass and Pass a Loutre.—A. Oh, they did?

Q. Yes. That is, it was like putting in a sill. It was a sill of mats they put out in the bed of the stream to make it higher and to force the water into the South Pass, where they intended the channel to be.—A. Yes; otherwise, if they hadn't put that sill in, the channel would have been cut so deep that there would have been no flowage of water through the jetties. I think that those jetties ought to be raised; that is, wherever there is a flood gets over the boards or the mats it will check the current.

Q. Did you investigate the matter of floods last spring? Did you study that question—keep track of it?—A. Of course I did.

Q. What conclusion did you come to in reference to the flood last spring, both as to the causes of it and the remedy for it?—A. I have thought of the remedy more than of the causes. And the remedy is, as I tell you, deep river and pools.

Q. Deepening the river and making pools in it by the method you have suggested?—A. Making slacker water. It will not only relieve the floods down there, in my opinion, but it will make good steamboat navigation, so that steamboats can come up to St. Paul during all of the open season. You will find that Captain Abbot's idea corresponds with mine exactly in regard to the wing dams.

Q. Have you laid your plan before Captain Abbot?—A. No, sir; I am not acquainted with him, but I sent this sketch down to General Wilson, and he returned it to me. He said he had received my plans, and he said they deserved great consideration (I think that is about the wording of it), and that he would see that they had consideration. Now, I claim that this system (producing another sketch) will relieve New Orleans against the floods. Have an opening, we will say, five or six hundred feet wide, with scows across having slide boards to raise up and down, and have the slide boards shoved down during low water so as to throw all the current into the jetties——

Q. Where would you have the opening?—A. At the upper end of the jetties. The opening is through the jetties, you understand.

Q. You would place the scows, then, at the opening in the jetties?—A. Yes, sir. I don't use the dredging apparatus there at all; this is merely to relieve the high water at New Orleans, you know.

Q. Well, you know the jetties are away down, over 100 miles below New Orleans?—A. I know; they are 130 or 140 miles, but there is a backwater there.

Q. Do you mean to say that by putting your scows at the mouth of the Southwest Pass, where the jetties begin, that that would relieve the flood at New Orleans?—A. That is my opinion. My opinion is that the sill in the Southwest Pass and the contraction of the water through the jetties would make a sort of a dam, as it were.

Q. Well, what bearing would your scows have, and in what way, upon the current of water there in the jetties?—A. For instance, there is a heavy flood coming down the river and passes down by New Orleans—

away down. I think that the jetties and the sill would, as it were, be a check for the current. That is my idea.

Q. You mean the sill that is already in there?—A. Yes, sir.

Q. That and the jetties would check the current?—A. Would necessarily, in my judgment, check the current.

Q. Well, those are in there now.—A. I know; that is what I say; it must check the current.

Q. Well, what would you do then?—A. I would cut a channel through one side of the jetties, so the water could go through when it is high.

Q. Instead of having it follow down the whole jetty?—A. Yes, sir. I would make it at the upper end of the jetties, and when the floods begin to subside I would shut those down, so as to compel the water to run through the jetty.

Q. That is, at high water you would open what you might call waste gates?—A. That is exactly it.

Q. At the upper ends of the jetties?—A. Yes, sir.

Q. And at low water you would have those closed?—A. Yes, sir; shut down and closed as soon as the flood begins to subside. That is my idea.

Q. That would be to hasten the flow of water down there.—A. Yes, sir.

Q. It would enable part of the current to pass down in the jetty channel and part to flow out through those waste gates?—A. Yes; to pass through the waste gates in high water, but when the flood begins to subside I would have the slide boards (or waste gates, as you call them) shoved right down to the sill.

Q. When the flood begins to subside you would force all the water between the jetties?—A. Yes.

Q. And at high water you would let it run at the sides through those waste gates?—A. Yes. Now, if you will make inquiries I think you will find that the water gets over the top of those jetties and checks the current, and by doing so naturally there will be a deposit of silt close to the end of the jetties, as there wouldn't be strength of current enough to carry it beyond the ends of the jetties.

The sketch produced by the witness as illustrating a method of relieving floods at New Orleans was marked "Exhibit P," and will be found on page 165.

Q. Have you given any consideration to what they call the outlet system, the means of relieving the river by means of outlets?—A. I have read a great deal about that.

Q. Letting the water out through Lake Borgne and through the Atchafalaya?—A. Yes, sir; I have.

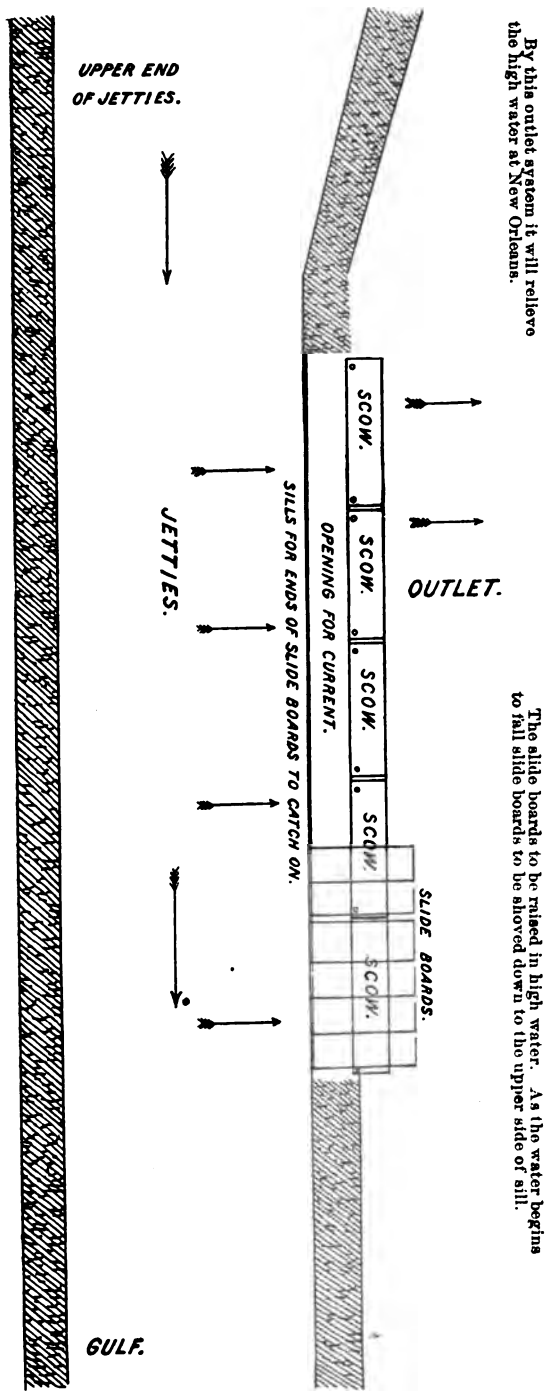
Q. Through Bayou Plaquemine and Bayou Lafourche and other streams there, and into Lake Borgne or Maurepas and Pontchartrain?—A. Yes.

Q. Through Bayou Manchac and some of those other bayous there. Now that is what they call the outlet system. What do you think of relieving the river by means of the outlet system?—A. If they cut a channel it will ruin the jetties just as sure as you sit there.

Q. And ruin the stream?—A. And ruin the stream.

Q. And you think it is unwise and unsafe?—A. I do. Take any of those islands; take Pigs Eye. By dividing the current there you are sure to have a bar. I have been over that stretch of the river many and many a time. Now, when you stop up the head of an island and concentrate the current, you will have a channel on one side. It is a grand thing they have done here in regard to stopping up the heads of islands, throwing the channel all into one.

EXHIBIT P.


By this outlet system it will relieve the high water at New Orleans.
The slide boards to be raised in high water. As the water begins to fall slide boards to be shoved down to the upper side of sill.
UPPER END OF JETTIES.
SCOW.
SCOW.
SCOW.
SCOW.
SCOW.
OUTLET.
JETTIES.
OPENING FOR CURRENT.
SILLS FOR ENDS OF SLIDE BOARDS TO CATCH ON.
SLIDE BOARDS.
GULF.

Q. You think that is a good plan, don't you?—A. Oh, it is a grand plan.

Q. Keeping the river in one channel?—A. Yes, sir.

HARRY N. PHARR, sworn, testified as follows:

Examined by Mr. NELSON:

Q. What position do you hold, Mr. Pharr?—A. Chief engineer of the St. Francis levee district of Arkansas.

Q. You are under the Mississippi River Commission?—A. No, sir.

Q. Under the State authorities?—A. Yes, sir.

Q. How long have you held that position?—A. Since the 1st of November of last year; first assistant engineer for several years before that time.

Q. What does that levee district include?—A. It includes the overflowed district in Arkansas lying between the Mississippi and St. Francis rivers and a small portion west of the St. Francis River.

Q. How far up the river—to what point?—A. To the Arkansas and Missouri State line. That is as far as the Arkansas district goes.

Q. You succeeded your father in this position?—A. Yes, sir.

Q. He had held it for years?—A. Yes, sir; since its organization.

Q. How long ago?—A. It was organized in 1893.

Q. Does your State build levees also?—A. The district builds levees.

Q. Under State authority and with State money?—A. No, sir; district money. It is a State organization.

Q. You are a State organization, operating under State authority, but building levees with Federal money?—A. No, sir.

Q. State money?—A. District money.

Q. I mean it is money raised under your State government?—A. Yes, sir.

Mr. BERRY. Under the law of the State, but it is only levied on that district.

The WITNESS. Only levied on the district; yes, sir.

Mr. BERRY. Not through the entire State?

The WITNESS. No.

Mr. CATCHINGS. Has the levee board power to levy its own taxes, or does the State levy them?

The WITNESS. The levee board.

Q. You levy taxes on the property subject to overflow?—A. Yes, sir.

Q. Is there any limit to the taxes you can levy?—A. Yes, sir.

Q. Is all the land subject to overflow in your State owned by private individuals, or is any part of it State or Federal land?—A. There is a small portion that is yet Federal land, and some that is owned by the levee district, that is, that the State gave to the levee district for levee purposes when they organized.

Q. Can you tell approximately the acreage within your district of the overflowed lands, the total acreage?—A. About 2,000,000 acres.

Q. And about what proportion of that is owned by the Federal Government?—A. The land owned by the Federal Government is not included in that. It is land that was never surveyed.

Q. That is outside of the 2,000,000 acres?—A. Yes, sir.

Mr. BERRY. Known as the sunk lands, is it not, a good deal of it?

The WITNESS. Yes, sir. It is sunk land that was not sectionized when the Government survey was made. It amounts to only four or five thousand acres in the district; that is all the Government owns.

Q. About how much of the 2,000,000 acres of overflowed land belongs to the State of Arkansas or has been transferred by the State to your

levee district—I mean public lands that do not belong to private individuals?—A. The levee board owns a little less than 200,000 of the 2,000,000 acres.

Q. Has the levee board got all the State lands that were in the district?—A. Yes, sir; by an act of the legislature.

Q. So that all the rest of the 2,000,000 acres is private property?—A. Yes, sir.

Q. What is the limit of the tax the levee board can levy on property?—A. The limit is 5 per cent.

Q. Five per cent of the assessed valuation of the land?—A. Yes, sir. The statute authorizes the levy of 5 per cent, but our lands are not valued like lands are generally for State and county taxes; they are valued at so much an acre, and then they are equalized. For instance, they will take a cleared acre of land and value it at $50, and they will take an acre of wild overflowed land and assess it at a dollar, then they add the whole thing together and divide it up so as to make 4 cents an acre; in round numbers we assess 4 cents an acre on lands in our district. That is about what we levy. That is done by a vote of the people. It has to be submitted to them before it can be levied at all.

Q. Has any levee been built along the Mississippi River in front of your levee district?—A. Yes, sir.

Q. Approximately how much has been built by the district alone?—A. At the end of this year the levee district alone will have expended $342,500.

Q. How many miles of levees have you built?—A. We have built 80 miles, at the end of this year, at the end of the present contract.

Q. Did you begin at the lower end of your territory or at the upper end?—A. At the upper end.

Q. You built from the State line down?—A. Yes, sir.

Q. Have you finished the section opposite your district?—A. No, sir; we still have 95 miles open.

Q. Are the 80 miles that you have built completed?—A. It will hold a 49-foot stage of water at Cairo without a break.

Q. Has it been completed according to your plans, or is the work still progressing?—A. Part of the work is still progressing.

Q. Was this 80 miles completed a year ago, at the time of the big flood?—A. No, sir; there was only 63 miles built then, and part of that was old levee on which no work had been done.

Q. Now, in what portion of the levee that was then built did any crevasse occur, if at all?—A. The first crevasse in Arkansas was just below Osceola, Mississippi County, in the old State levee, but which had been raised by us.

Q. About how far below the Arkansas line?—A. About 33 miles.

Q. How wide was that crevasse?—A. About 600 feet wide.

Q. And how long was it open before you repaired it?—A. The work of repair has just been finished.

Q. You did not undertake to repair it during the pendency of the flood?—A. No, sir.

Q. Did you have any other crevasses?—A. Yes, sir.

Q. Where were they?—A. From that first crevasse, around Craighead Point to Nodena, about 16 miles, it was an old levee, built under the State organization, back in the fifties, and had never been repaired by the district.

Q. How big was that crevasse?—A. Well, I say that the next 16 miles was——

Q. Was all a crevasse?—A. All broken up pretty badly; yes, sir.

Q. Overflowed, the whole of it?—A. Yes, sir.

Q. Has that been repaired?—A. That has been abandoned, and a new levee has been built there.

Q. Inside of it?—A. Inside of it. Across the point.

Q. Did any more crevasses occur at that time?—A. No more in Arkansas.

Q. What is the height of this new levee that you built?—A. It has an average height of about 9 feet from the State line for the 80 miles that we have just built.

Q. Do you know from what cause this new levee broke? Was it because it was not high enough, so the water would run over it, or was it because of some other defect in the levee?—A. No new levee broke in Arkansas. The old levee broke in many cases because it was too low. In other cases it was because of the way it was constructed.

Q. Taking the flood of 1897 as a basis, would that levee that you have constructed be high enough for such a flood, or would you need a bigger levee?—A. We need a bigger levee.

Q. Heavier?—A. Heavier and higher.

Q. How much higher?—A. We would like to have it 2 feet higher.

Q. To make it safe?—A. To make it perfectly—well, one that we can expect to hold.

Q. Now will you make a statement of such things as you deem material in reference to your levee district?—A. I wish to submit to your honorable body for your consideration information as to the condition of this levee district, what we have done, what we hope to do, and to set forth reasons why we justly claim your favorable recommendation of our requests and hearty cooperation in our undertakings—argument and reason by eminent engineers why this basin should be closed to lower the high-water mark at Helena and relieve the levee systems below, both as to height and duration of flood.

We know that a successful retention of the floods from our basin depends greatly upon the maintenance of the levee of the St. Francis levee district of Missouri, of which my predecessor, the late Capt. H. N. Pharr, was also chief engineer, and I am able to furnish you with information as to the work they have accomplished.

The St. Francis levee districts of both Arkansas and Missouri were organized in 1893, since which time and up to the date of the last annual report of this department (May 6, 1897) the following work has been done and expenditures made by the respective districts and by the United States Government:

The Missouri levee district had built 1,045,865 cubic yards, at a cost of $127,300.83; the Arkansas levee district had built 1,275,932 cubic yards, at a cost of $240,041.31, making the total expenditure by the two districts $367,342.14, and a total yardage of 2,321,797 cubic yards. The United States had built in Missouri levee costing $79,945.67, and had built in Arkansas levee costing——

Mr. BERRY. Within the St. Francis district?

The WITNESS. Yes, sir.

Mr. BERRY. In Arkansas within the St. Francis districts?

The WITNESS. Yes, sir. The Government had built in Arkansas levee costing $154,091.01. The total levee built in Missouri by the Government and the districts amounted to 1,885,543 cubic yards, at a cost of $207,246.50. The levee built in Arkansas, both by the district and the Government, amounted to 2,195,769 cubic yards, at a cost of $394,132.32. The cost of all the levee built in both districts, both by the district and the Government, amounted to $601,378.82, and the yardage amounts to 4,081,312.

ATCHINGS. That is, both district and the Government, in both s?

WITNESS. Yes, sir.

overnment and State, in both districts?—A. The Government districts; yes, sir, in both districts. The above does not include vork, then under construction by the United States Government, iles from Bear Bayou south, which has since been completed t about $27,000—making the total expenditure by United States ment in both districts $261,036.68, and the total expenditure by stricts of $367,342.14.

United States Government has now under construction and about ted closing of breaks and repair work in Missouri, estimated to 1,000, and closing of breaks, repair work, and new levee across ead Point, in Arkansas, estimated to cost $56,000.

Missouri district in building their front of 47 miles with the help of vernment, anticipated their revenues to such an extent as to have able to do any work this year (fiscal). The St. Francis levee of Arkansas, however, has forged ahead, and has now under ction and near completion 8 miles of repair work from above to below Osceola, which is estimated to cost $16,000; topping miles of levee between Nodena and Pecan Point, which is ed to cost $5,500, 17 miles of new levee—in prolongation of our ous line—from Pecan Point south, estimated to cost $75,000, ve agreed to supplement Government fund, and have entered ntract to have completed by the 1st of March of this year that the new levee across Craighead Point, which the Government lotted will be insufficient to close. This distance is one-half of and is estimated to cost about $6,000, showing a total of enlarge- losing of breaks, topping off and new work, exclusive of Gov- t work, at the present time under construction, of 34½ miles, and ted to cost $102,500.

gentlemen, is a magnificent showing; showing the desire of trict to be leveed and the determination of this board to succeed. e date of our next annual meeting I shall be able to report about ws:

	Cost.
levee district has built 1,045,865 cubic yards	$127,300.83
s levee district has built 1,939,932 cubic yards	342,541.31
tal by two districts, 2,985,797 cubic yards	469,842.14
ted States Government will have spent in—	
ouri about	91,000.00
nsas about	237,000.00
tal United States work will have cost	328,000.00
ree built in Missouri will have cost about	218,250.00
ree built in Arkansas will have cost about	579,630.00
tal cubic yards costing	797,880.00

is our showing for the past, since our organization in 1893. gh our hopes in the past have often been disappointed we have wed ourselves to become discouraged, and we believe that in a hile we shall see our basin of 6,000 square miles protected from Point Pleasant, Mo., to the mouth of the St. Francis River in as, a distance by levee of 222 miles. The above cost has given tinuous levee from Point Pleasant, Mo., to Chute 38 in Arkansas, nce of 127 miles, and although the flood of 1897 demonstrated

the fact that nearly the whole length of this levee is too low, and should be enlarged and raised at least to a grade of 2 feet above that water, yet we think we can hold a 49 or 50 foot water at Cairo for the entire length.

Q. At Cairo the water was then 52 feet, was it not?—A. 52.3 is the highest water at Cairo that we have ever had. Last year it was 51.6.

Q. 51.6 above low-water mark?—A. Above zero on the gauge. In 1892 there was held in the city of Memphis a meeting at which were present the civil engineers representing the local levee boards below Memphis, Government engineers interested in the improvement of the Mississippi River, business men of Memphis, and others, the object being to urge the citizens of the St. Francis Basin to meet, organize, and build the levee along the entire front of their basin from Point Pleasant to the mouth of the St. Francis River, and declaring it to be the opinion of the meeting that the leveeing in of said basin would shorten the duration of the flood. This district was organized and we have built about half of our levee in length. This without their cooperation or assistance, and, I am sorry to add, in a few cases their antagonism. Eminent engineers who a few years ago declared it to be the result of their research and study that leveeing the St. Francis Basin would both lower the high-water mark at Helena and shorten the flood period have become indifferent to such an extent as to withhold their aid. Others have allowed "public opinion" to defy their opinion, which has been formed by the study and reason of a lifetime, and remain silent as to erroneous assertions or meekly consent. Others have fought openly, and Maj. T. G. Dabney, Chief Engineer of the Upper Yazoo levee district of Mississippi, declared it as his opinion, in a resent report to his board, that the success of their levees, until they had raised and strengthened them almost beyond a possibility, depended upon the failure of this district and of the Upper White River district in Arkansas from Helena down.

Our contention is, that the total leveeing of this district from the highlands above Point Pleasant, Missouri, to the mouth of the St. Francis River will raise the water at intermediate points between Point Pleasant and Memphis, but will lower the high-water mark at Helena, and relieve the levee systems below. In support of this I have the opinion of Colonel Suter, Corps United States Army Engineers, who was lately a member of the Mississippi River Commission and president of the Missouri River Commission. (See report of Mississippi River Commission, First session, Fifty-fourth Congress, Appendix I):

> In a general way it has been shown that the large increase of flood height has been mainly confined to intermediate points along the great swamp basins. At the lower end of these basins it has been slight, as for instance at Vicksburg. The only feature of uncertainty which now remains is the effect of leveeing the St. Francis Basin. That this will increase flood heights at Memphis and all points above there seems certain, but so far as concerns the river below Helena there is this much to be said: All of the water which reaches the main stream above the junction of White River now passes Helena between levees, and hence has probably produced its maximum effect.

Major Richardson, chief engineer of the Louisiana State board of engineers, and Maj. Wm. Starling, chief engineer of the Lower Yazoo district, have given opinions and reasons to the same effect.

My predecessor as chief engineer of this levee district in a letter addressed on the 24th day of August, 1898, to the Hon. P. D. McCulloch, at present a member of the River and Harbor Committee of the House, representing the First Congressional district of Arkansas, of which the St. Francis Levee district of Arkansas lies wholly within and constitutes about half, argues and explained the probable consequences to

heights of leveeing this basin in such a fair, plain, and painstaking ner, that one of your present members of this subcommittee has ounced it unanswerable. He shows that the river is composed of ies of pools and shoals; that "the conditions of a uniform plane is blished at 40 feet on the Helena gauge, and thereafter a 1-foot rise emphis makes 1 foot at Helena; hence when the restrained flood feet makes 39 feet at Memphis it will make 49 feet at Helena, and make no more." He rightly attributes the sudden rise and long tion of the water at Helena at a high stage to the return flow of water which has gone over the bank of the river all along the front ie basin, suddenly returning to the basin stream at the mouth of St. Francis River, and finding a stage of water in the Mississippi h has not yet begun to fall suddenly carries the Helena gauge 2 feet higher than it should go—if this return flow was done away and passed off as it came beween levees—and holds it there, even inuing to rise from ten to twenty days, in which time the Cairo ge has often fallen from 10 to 15 feet. A fall at Cairo with the basin ed should give a fall four days later at Helena. He says of the nd rise of 1893:

mphis by a rise of one-tenth of a foot the next day (May 9th) reached its maxi- in that flood, while Helena reached its maximum, 47.9 feet, twelve days later. s thirteen days from the date that the crest of this wave passed Cairo until it ed Helena, a sufficient time for it to have reached the Gulf, had it been re- ied between levees along the St. Francis front. Cairo had fallen 12 feet when ia reached its maximum.

is basin is no reservoir to relieve the levee systems below, but er acts as the breaking of a dam to flood the river at Helena and the high-water marks below. We grant that it would be a reser- could the water that fills this basin be accumulated and held here the main river has subsided to a sufficient extent to carry it off out excessive flood heights. But we have no control of the distri- on, nor can we retain it; it is delayed by the underbrush and three of railroad to an extent to dam it up and accumulate—taking from t to fifteen days to go a distance it would go in three days if held ie river—until it neared the mouth of the St. Francis River, when es like the breaking of a dam to flood the Mississippi at their con- ice, raise the water at Helena and all points below.

ubmit herewith the letter referred to in pamphlet form, also con- ng a letter of January 15, 1897, addressed by my predecessor to G. L. Gillespie, Corps Engineers, United States Army, and pres- t Mississippi River Commission, in support of his former arguments ring that closing the St. Francis basin would not raise the high- r mark at Helena. He considers the gauge readings and discharge rvations for several years:

se gauge relations prove conclusively the truth of my contention, that the ia gauge does not maintain any certain relation to the Cairo gauge, but does very close relations with the Memphis gauge from 30 feet on its gauge until phis reaches its maximum reading, which gives about 44.5 feet at Helena, at h stage Helena discharges the greatest flood that passes Memphis, and that if ig our front should raise Memphis 3 feet—an impossibility—Helena would dis- ge it on less than 48 feet, her present high-water reading.

further confirmation of this, see Table V, discharge relations een Cairo and Helena. He has referred the Columbus discharge ie Cairo gauge; this shows that the maximum discharge for the of 1892 at 50.8 feet was 1,558,000 cubic feet per second. Helena, same year, gave exactly the same discharge at 47.1 feet on its ge, a difference of 3.7 feet, showing that Helena, with a gauge read- 3.7 feet less than Cairo, can pass as much water at that stage.

Then 52.3 feet at Cairo, if restrained between levees, should be passed on a gauge of less than 49 feet at Helena. The pamphlet was marked "Exhibit Q," and is as follows:

EXHIBIT Q.

BUILDING THE ST. FRANCIS FRONT LEVEE WILL NOT RAISE THE WATER MATERIALLY AT HELENA NOR ENDANGER THE LEVEE SYSTEM BELOW.

[By H. N. Pharr, Chief Engineer St. Francis Levee Board.]

OFFICE CHIEF ENGINEER ST. FRANCIS LEVEE BOARD,
West Memphis, Ark., August 24, 1896.

Hon. P. D. MCCOLLOCH, M. C., *Marianna, Ark.*

DEAR SIR: In response to your suggestion that I furnish you with a discussion of the Mississippi River, I respectfully submit that that river is governed by the same laws that govern the branch that flows from the spring or the creek that flows through the meadow.

You remember the dams you and your playmates built of gravel, sand, and mud across the branch and watched it filling the basin thus formed until it finally burst the dam and rushed down its channel, carrying gravel and sand with it. Following it down the stream you observed that its volume soon began to change form. The tendency was to elongate and subside. This continued until in the distance your flood disappeared. As it subsided you noticed that it began to drop its load, first its heavier part along the bottom of the channel and the sand along its convex banks, especially below the apex of the curve. Thus are shoals built in the channel and sand bars extended downstream.

Then you had a flood wave governed by all the laws that control such waves in the Mississippi River.

There is a certain force of gravitation (weight) inherent in each atom of water. This accumulates as the volume increases, and while the volume is restrained it remains apparently latent, but is never latent. It was this force that burst your dam and started the flood downstream.

As soon as water begins to flow it acquires a second force, due to its velocity, and the resultant of these two forces, its momentum, is the working force of the stream at whatever stage it may be.

When we remember that water flows, i. e., it moves by an interchange of atoms, which is so easy as to be excited by the least provocation, that this flow is governed wholly by its depth or aggregated weight and the inclination of the channel, which fixes its velocity, modified by the friction it encounters, each atom moving for itself under these laws, and is not in any sense projected or driven forward by an exterior force—an error into which some eminent engineers have fallen—and that all waves subside by their own weight (gravitation), hence we are able to understand why your flood wave in the branch subsided. It did subside by increasing its length, because its banks restrained its width. The crest of the wave produced this elongation by restraining its rear and accelerating its front. Thus a stream flows faster as it rises than as it falls. Hence, all conditions being the same, a flood wave of any height will pass no two points at the same elevation. The difference will be in proportion to the distance, or the same thing, the time.

If we now leave the spring branch and go down to the creek we will find it, as you well remember, composed of a series of pools and shoals. A moment's observation will suggest the fact that no more water flows through the pools, whatever their capacity, than passes over the shoals. A difference in velocity is at once observed. This difference shows that there is a difference in their planes or a difference of "slope." The shoals more inclined, the pools less so. That is, the low-water service is a series of planes, making angles more or less with each other.

If we follow the creek down to the old milldam we find on our way that when we come to the head of the "mill pond" the creek just above is flowing on as if there were no dam across the creek and no pond there. If, on reaching the dam, we estimate the pond to be 1 mile long and find the dam to be 8 feet high, observing the surface of the pond to be practically level, we infer that the slope of the channel is about 8 feet to the mile. That is, the dam does not in any way affect the flow of the creek above the point at which a horizontal line laid on the surface of the pond reaches the bottom of the creek above.

We have seen such floods come down the creek as to cause the shoals to disappear—even the pool below the dam was filled and the water ran smooth over the dam. The dam is but a greater shoal in the creek. From this we learn that while the low water lies in a series of planes, more or less inclined, the effort of the water as it rises is to assume a uniform plane, and its nearest approximation of such plane is its high-water line.

it is plain that no water runs through the pool below the dam that does not r it, though it is wider and many times deeper than a cross section on the uld show. And it is just as plain that all the water that runs over the dam rough the pool, and that it takes a certain depth of water on the dam to he pool and maintain the uniform plane of the high-water line, and that no ɴd depth on the dam can raise the pool above that plane.

› creek we have the river, differing only in such exaggerated features as art has ɴd. If we now turn to the Mississippi River, we find the gauge reading of high s follows: Cairo, 52 feet; New Madrid, 47 feet; Cottonwood Point, 37 feet; , 33 feet; Memphis, 35 feet, and Helena, 48 feet. This shows us very plainly that a long shoal between Cairo and Helena, built up, doubtless, by long ages of ɔverflow. To understand this it is only necessary to remember that the work- e of water is proportional to its depth multiplied into its velocity. Anything ries either or both of these factors varies that force. Now, that force is per- y occupied in an effort to remove matter from a higher to a lower plane, and works to its full capacity; as it finds the banks and bars of the river an easy goes loaded.

verflow reduces both the depth and velocity—the depth by so much as is due to ıme of outflow, the velocity by so much as is due to the reduced depth added nfluence of the cross or counter current of the overflow. Thus is the force , which at once drops so much of its load as is due to that reduction, and .re built along and below outflows.

ıhoal between Cairo and Helena is distinctly shown by a profile of the zero ;auges, and if the profile be extended it will show the river to be composed ies of pools and shoals to New Orleans just as we have seen in the creek.

amining the record of the reading of the gauges from Cairo to Helena for a of years we find that the water rises faster at Cairo and Helena than at any ɔtween; that is, as a rise comes on the pools fill up. Under the same con- the relations between these gauges continue up to 40 feet at Cairo, which gives 0 feet at Memphis and 40 feet at Helena. Up to this line the river is practi- not strictly within its banks, and the gauges show that 12 feet at Cairo feet at Memphis and 12 feet at Helena. Above that line the outflow disturbs ɪtion. The next 12 feet at Cairo gives but 5½ feet at Memphis and 5 feet at

ɴe that 3½ feet of this 9 feet due at Memphis to this last 12 feet at Cairo has er the bank. If restrained between banks 52 feet at Cairo would give 39 feet phis, less whatever may be due to increased velocity due to 3½ feet increased This is all the extremists can claim.

rhy does the 5½ feet at Memphis which has remained in the channel make but t Helena and not 7½ feet as heretofore? Plainly because the Helena Pool has ; 40 feet on that gauge and is delivering over the next shoal below the water mes; that is, the conditions of a uniform plane have been established at 40 that gauge. Thereafter a 1-foot rise at Memphis makes 1 foot at Helena; rhen the restrained flood of 52 feet at Cairo makes 39 feet at Memphis it will 9 feet at Helena, and can make no more. Hence, having the St. Francis Basin :an not raise the high-water line a foot at Helena, but will doubtless restrain tly, which reduction will continue as the shoals are scoured out by the re- l flood.

tenths of all the water that heretofore has flooded the St. Francis Basin left ɔr between Point Pleasant and Bear Bayou, a distance of 66½ miles. That n leveed, and the next flood will doubtless show a higher water line, due to trained outflow. This increased height of water line has been called an mal" rise, due to the restraint—a secondary wave on top of the primary and for evident reason it must subside more rapidly than the primary wave. I say 52 feet at Cairo can never make 39 feet at Memphis nor 49 feet at Helena. this conclusion it is unnecessary to discuss the results from closing the St. Basin upon the river below (they are prepared for 48.8 feet at Helena) fur- an to say that it will be very much to their advantage in this, that it will the high water period by from ten to forty days. It is not, as a rule, the of the water that breaks levees, but the long-continued pressure; that is, it t run over levees, but works its way through.

u ask why, if this be true, the contention that now exists from Helena to the ;ainst closing the St. Francis front, and why do the engineers sustain that ion? I confess it is not easy, from my standpoint, to answer that with the ation its importance demands.

great many years these people have been building levees. They have closed ıin after another. In each case there were not wanting prophets who pre- the most calamitous results to follow, and those whose interests were to be l became their ready followers. As one prediction failed it was transferred ıext case and their following increased by those to be affected until the whole seized by a nervous apprehension of an imaginary calamity, and this not-

withstanding the fact well known to them that closing the Yazoo front for more than 60 miles above did not raise the high-water line one foot at Helena, nor did closing the whole front of the great Yazoo Basin raise the high-water line one foot at Vicksburg.

Their predictions having failed up to this time, they now turn their attention to the St. Francis front with renewed energy. They determined that that front should not be leveed until they were certain of their own safety, while they have no idea what will give that safety. If their levees were built 10 feet higher and some new prophet, or some old one not yet exhausted, should raise the cry of impending ruin "the fat would be in the fire again."

Their scheme to prevent closing the St. Francis front was to exhaust the late appropriation by the Government for levees by exorbitant demands upon it. If they could exhaust that one they could exhaust the next, if any, and so on.

But to exhaust the appropriation they were sorely in need of some fact upon which to base their claims before the Mississippi River Commission. That fact they produced in the shape of an "abnormal" rise of 4 feet in the river, due to the closure on a few miles of a gap in the White River front. No matter if the river was but 1.4 feet above the danger line and the outflow could not have been 1 per cent of the volume that passes over the front at very high water; no matter if closing the Yazoo front of twenty times the outflow restrained by the White River levee produced an abnormal rise of 4 feet nowhere; no matter if closing any other basin had produced no such abnormal rise; no matter if credulity was taxed to a point at which reason revolted, it was a necessity in their case, which was urged by such earnest persistence before the commission as to cause them to assume a waiting attitude as to the St. Francis front.

Is it surprising that the engineers, who a few years before held a convention in Memphis to urge upon the citizens of the St. Francis Basin to organize and build that levee, not only for their own protection, but also for the protection of the whole levee system below by reducing their high-water period, should discard all former experience, abandon their lines of reasoning, and surrender their judgment to that nervous apprehension of calamity which pervades all classes, of which Colonel Suter, Corps of Engineers, U. S. A., member of the Mississippi River Commission and president of the Missouri River Commission, than whom no one is more competent to speak on any subject relating to the Mississippi River, says (see Report of Mississippi River Commission to first session Fifty-fourth Congress, Appendix I): "* * * The great progress made of late years in levee construction, coupled with the probability that in a few years the system will be substantially completed, has naturally aroused much interest throughout the whole valley of the Lower Mississippi. The increased flood heights due to this artificial restraint, although fully expected and predicted beforehand, have nevertheless created much anxiety among those persons who are personally interested in the matter and have aroused much apprehension as to what the final outcome will be. This feeling is by no means confined to ignorant persons, professional alarmists, and cranks, but affects also so many persons of intelligence and influential position that some expression of this feeling in the shape of adverse legislation is much to be apprehended. This being the case, it seems to me to be the imperative duty of the commission to prepare for such a contingency beforehand and to avert, if possible, such action by such a statement of facts as will serve in some measure to relieve the public mind. In a general way it has been shown that the large increase of flood height has been mainly confined to intermediate points along the great swamp basins. At the lower end of these basins it has been slight, as for instance at Vicksburg. The only feature of uncertainty which now remains is to the effect of leveeing the St. Francis Basin. That this will increase flood heights at Memphis and all points above there seems certain, but so far as concerns the river below Helena there is this much to be said: All of the water which reaches the main stream above the junction of White River now passes Helena between levees, and hence has probably produced its maximum effect. There seems little reason for thinking that the height reached in 1886 will be much exceeded by any such floods as heretofore experienced." * * *

I wish to add that since our levees have assumed such proportions as to be very costly their permanency becomes a question of much concern.

As long as the flood which drops more or less of its load along convex shores and is able to reload from the concave banks easier than from the bottom, the caving of the banks must continue and the deepening of the channel by scour must be retarded. Some method of controlling the current so as to protect the banks has long been an evident necessity to the levee system. The revetment idea at first inspired some hope, but it was soon seen that its cost and want of permanency would confine it to a few points where immediate relief was needed, and there to such an extent only as would permit of frequent rebuilding. As a project to control the river to such an extent as to protect the levees it was impracticable and doubtless never intended by the commission. It partook too much of that strategy which attacks an enemy in his own strongholds. It was therefore with much satisfaction that we saw the dredging

'table dike idea introduced, which, if wisely applied, will not only effect the ng of the channel, so much desired, but in that very act throw the current the convex shores, cut off the bar and build up the concave bank. The hing is to get the current into the "middle of the road" and keep it there. ıful am I of this project that I bespeak for it whatever support your official ı may enable you to give the commission.

espectfully, your friend, H. N. PHARR.

OFFICE CHIEF ENGINEER, ST. FRANCIS LEVEE BOARD,
West Memphis, Ark., August 24, 1896.

D. MCCULLOCH,
Marianna, Ark.

EAR FRIEND: I herewith hand you a paper intended to be a compliance with quest that I furnish you with my views of the results of closing the St. Francis

e endeavored to avoid technicalities. I am pleased to know that I am sus- in my opinion by such eminent authorities as Colonel Suter, whom I have and Judge Taylor, who, in his address before the Deep Water Convention , discussed the whole question of abnormal rises most intelligently, and, as ıtless reflected the opinion of the board, we thought it unnecessary to go into ment to refute the assertions made and deductions claimed by the lower dis- ınd were greatly surprised by the action taken by the commission.

at action affects most vitally nearly one-half of your entire district, the com- could not think it impertinent in you to take some notice of the allotment

ınderstand the situation fully—how the discrimination against our district boldened our enemies and discouraged our friends to such an extent as to very much our credit and threaten the integrity of our organization, than ıo greater calamity could befall us.

hundred thousand dollars would build our levee to a safe point below West is, which would protect a very large part of our district and relieve more or remainder.

ıg that you may have some opportunity to aid us in our appeal to the com- for reallotment,

remain your friend, H. N. PHARR,
Chief Engineer St. Francis Levee District.

OFFICE CHIEF ENGINEER ST. FRANCIS LEVEE BOARD,
West Memphis, Ark., January 15, 1897.

L. GILLESPIE,
resident Mississippi River Commission, Army Building, New York City.

NEL: In support of my former arguments, showing that closing the St. Fran- t could not affect materially the Helena gauge, I herewith submit the gauge s of the floods of 1890, 1891, 1892, and 1893, in tabular form, arranged to me, for Cairo, Memphis, and Helena; also the result of discharge observa- milarly arranged for 1882, 1892, and 1893, as far as simultaneous observations ı points will permit.

nd, upon examination of these gauge readings, that Cairo exceeds Helena rom low water to 10 feet, at which stage they are about even; Helena stead- ıs on Cairo gauge from 10 to 30 feet; from 30 to 37 feet Cairo gains all it has d passes Helena gauge. Helena, at 37 feet on its gauge, abandons Cairo es a ratio of equality with Memphis. This it holds up to 44 feet on its gauge, h time it begins to feel the return flow from the St. Francis Basin, and at creases its rate of rise independent of Memphis or Cairo.

ɔ aberrations within certain limits are evident the relations are sufficiently ı to establish the general law as above laid down. The exceptions appear when the river is subjected to several low waves (between 20 and 40 feet) ıg each other in quick succession, the succeeding wave overlapping, to some the preceding one. It is from the gauge readings for these waves that such elations have been found as to indicate that the Helena gauge generally, if ariably, exceeds the Cairo gauge, from which it has been argued that if the ncis Basin was closed the Helena gauge would preserve these supposed rela- ith the Cairo gauge to its maximum, giving 53 feet on the Helena gauge. ı Townsend, Corps Engineers, United States Army, lately in charge of the listrict, put forward this view with some persistency. His purpose was to ıat the St. Francis front should not be closed until an impossible amount of ıd been done below. He says: "It would require for the Lower Yazoo dis- 000,000 cubic yards to raise it 4 feet (the height he estimates necessary to hold

the St. Francis water), more than its people have been able to put up in twenty years," and of course a proportional amount for all other districts, according to their length. The life of a levee is estimated at twenty years. In twenty years they will have to rebuild all their present levees, which it has taken them twenty years to build. When, then, are they to add this 20,000,000 cubic yards or twenty years' work? I say it is an impossibility.

The conclusions arrived at by Captain Townsend appear to have been especially gratifying to riparian owners and others below us, who contemplate with satisfaction the idea of leaving the large area of this basin, lying in the heart of our country, unprotected; and the thousands of homes, farms and many villages to be devastated, lest closing it should do what closing no other basin has done—raise the high-water line hundreds of miles away from the point of restraint of flood to such an abnormal height as heretofore unheard of anywhere. Their selfishness in this certainly entitles them to assert great claims to human nature.

It was our purpose to review as briefly as possible some of the arguments and conclusions of Captain Townsend. For this purpose we have carefully studied his papers, submitted to your honorable commission, as contained in your reports. But we confess that we are wholly incompetent to cope with an engineer who conceives water to flow in column; that water, whether in a river, a pipe, or a pump, flows by the same laws; that the force which generates motion in a stream is "a pressure applied at one end of the column and opposed by a pressure at the other end;" that water uninfluenced by mechanically applied force flows in filaments; that damming up water is loss to its potential, an expenditure of energy, etc. Therefore, we pass much that he has said on the subject to get to his discussion of the return flow of the St. Francis.

He says that "after a time the water that has overflowed acts like a levee in restraining more water in the river channel and the flood surface rises, and no matter how much energy is lost through the forests and underbrush the St. Francis River still retains sufficient force to climb on top of the flood wave that passes its mouth." If he was correct in this, we might well rest our contention that closing the St. Francis front can not raise the high-water line at Helena upon his own conclusions. But we can not rest upon such a foundation of error as this.

His first assertion here is not supported by either experience or reason. No one has seen "the water that has overflowed acting as a levee restraining more water in the river, causing the flood surface to rise." There is no equilibrium of pressure between the flood in the channel and slack water in the basin. The flow is always from or to the river as it is rising or falling.

Along the river front, where levees are in near vicinity, the water on the bank, held by the levees, rises and falls readily with the river, and may have the appearance of restraining the flood to a casual observer, but a moment's reflection should show anyone that that water was held there by the levee, and any restraint it offered the flood was due to the influence the force of the levee transmitted through that water. As to the overflow unrestrained by levee in the basin. Admit it possible for a flood at some stage to fill the basin to a horizontal line tangent to its surface (the flood could not raise the basin above that line). Now give the flood but one more foot elevation, and what becomes of that foot? It, of course, goes out over the top of the water into the basin. Hence the water in the basin can never act as a levee to restrain more water in the river channel and cause the flood surface to rise. This is not pertinent to the subject in hand, yet I think it worth while to eliminate, as far as possible, the erroneous and confused ideas by which the subject has been enshrouded.

His second assertion, that no matter how much energy is lost through the forests and underbrush the St. Francis River still retains sufficient force to climb on top of the flood that passes its mouth, shows a still greater lack of thorough consideration of the subject. The water of the overflow loses no energy by its impingement against the forests and underbrush. Every obstacle to the flow of that water, if but a twig, impedes its flow, and whatever impedes its flow, however little, by that much dams it up and adds to its potential or head. This accumulation continues until the water attains such height, such weight, as to force itself through these obstructions with increased velocity. It crosses the Little Rock and Memphis Railroad 4 feet higher than the maximum gauge at Memphis, raising the water at Madison 18 feet in one day.

Of course the Mississippi River on one side and the St. Francis River on the other draw off the edges, so that the high-water line from Memphis to Madison is a curve, with a verse sine of 4 feet, while the accumulation higher up the basin is doubtless much more, for here it has begun to feel the draw of its debouche, and with accelerating velocity flows on to the river, giving the second impulse to the Helena gauge and carrying it to its maximum.

It is this accumulation in the basin that gives to Helena a higher reading than is due to the Cairo gauge, and higher than it would be if the St. Francis front were closed.

To illustrate the results of this accumulation—damming up of such a vast volume of water in that basin—let us suppose a levee built to a horizontal line along the western bank of the Mississippi River, 40 feet above the common surface at the mouth of the St. Francis River, the lower end resting on Crowley's Ridge, the other end would reach the ground near Memphis. Let a great flood pour into the basin until it reaches the top of our 40-foot levee. Let this levee, which would be 75 feet high across the channel of the St. Francis and a mile on each side, be swept out and that reservoir of 40 feet of water turned loose on the alluvial basin below. It would sweep it to the Gulf. Then, it is only in degree that this differs from the conditions in the St. Francis Basin during every maximum flood in the river.

But we are told that great abnormal floods will follow. We have heard but little of abnormal floods heretofore, though many of the great basins have been closed, and there is not enough data yet collected respecting these abnormal floods upon which to form a satisfactory opinion, but we submit that the effect of a crevasse is the converse of that of a restrained outflow of equal quantities. Reverse and invert the crevasse and we have an abnormal rise.

Returning to the tables hereto attached, and examining first the tables of gauge relations, Table I shows that on Jannary 5, 1890, a wave reached Cairo, which then had 23.2 feet on its gauge, giving 17.8 feet at Memphis and 24.1 feet at Helena. This wave reached its maximum at 43.7 feet at Cairo on the 20th, having risen 20.5 feet in fifteen days. Memphis and Helena each reached their maximum eight days behind time, on the 28th (Cairo time), at a reading on their gauges of 33.1 and 42.1 feet, respectively, having risen in twenty-three days at Memphis 15.5 feet and at Helena 18 feet. Cairo then fell 10.6 feet, to 33.1, on February 7, and Memphis and Helena reached their minimum the same day, at 24.4 and 39.5 feet, respectively, a fall of 8.9 feet for Memphis and 2.6 feet for Helena.

On the 8th of February a second rise reaches Cairo on its 33.1-foot gauge, and in eight days rose 8.8 feet, to 41.9, on that gauge. Memphis and Helena reached their maximum a day late, at 32.6 and 41.9 feet, respectively. Memphis rose in nine days 8.2 feet, but 0.9 of a foot less than Cairo, while Helena, in the same time, rose but 2.4 feet. From the 16th to the 24th Cairo fell 7.5 feet, to 34.4, while Memphis, to the same date, fell in seven days but 2.5 feet, and Helena reached its minimum of 40.6 feet on the 23d of February, a fall of but 1.3 feet to Cairo's 7.5 feet. I ask your particular attention to this, for it shows that these low waves following each other in quick succession give an abnormal condition to the river, and blending as they go, play havoc with gauge relations.

On February 24 the big wave of that year reached Cairo, found 34.4 feet on that gauge, and rose 14.4 feet in sixteen days, to 48.8 feet, its maximum. Memphis reached its maximum, 35.6 feet, a rise of 5.5 feet, a day later, while Helena continued to rise fourteen days longer and reached 47.7 feet, 3.4 feet of this came out of the St. Francis Basin. This table shows, upon further examination, the relation between Helena and Memphis is much closer than that between Helena and Cairo, the big rise giving a ratio of unity.

Table II, gauge relations between Cairo, Memphis, and Helena, for 1891, shows more plainly the sympathy between the Memphis and Helena gauges and disproves the assertion that Helena holds a ratio of unity with Cairo up to the overflow stage. If there is a ratio of unity between them at any time during this flood it is while Cairo is above the overflow stage, but even then it does not exist strictly.

This ratio between Memphis and Helena, as shown by this, is not unity invariably, but as nearly so as that between any two gauges on the river.

I consider a further discussion of this table unnecessary and ask your attention to Table III, gauge relations between Cairo, Memphis, and Helena for flood of 1892. Here we see that during the flood of that year, beginning on the 22d of March to the 12th of April, twenty-one days, Cairo rose from 25.5 feet to 45.8, or 20.3 feet; Memphis rose from 19.5 to 33.4 feet, or 13.9 feet, and Helena rose from 28 to 42.3 feet, or 14.3 feet. That is, in the twenty-one days Cairo rose 6.4 feet more than Helena, and Helena 0.4 of a foot more than Memphis. Here a fall or 1.9 feet at Cairo disturbed the gauge relations. Here we see a ratio of unity between Helena and Memphis, and not between Helena and Cairo.

Referring to Table IV we find Cairo and Helena running fairly together to 24.3 feet at Cairo on February 11, 1893. Here Helena goes ahead and takes a ratio of unity with Memphis and holds this ratio to its Memphis maximum stage.

The second rise of this year (1893), from April 11 to May 8, shows very distinctly the close relation between Helena and Memphis. On the 8th of May Cairo reached its maximum, 49.3 feet, having risen in the twenty-seven days 25.2 feet. Memphis rose in the same time 16.3 feet and Helena rose 16.3 feet.

Memphis, by a rise of 0.1 of a foot the next day, May 9, reached its maximum of that flood, while Helena reached its maximum, 47.9 feet, twelve days later. It was thirteen days from the date that the crest of this wave passed Cairo until it passed Helena, a sufficient time for it to have reached the Gulf, had it been restrained to

the channel along the St. Francis front. Cairo had fallen 12 feet when Helena reached its maximum.

These gauge relations prove conclusively the truth of my contention, that the Helena gauge does not maintain any certain relation with the Cairo gauge, but does hold very close relations with the Memphis gauge from 30 feet on its gauge until Memphis reaches its maximum reading, which gives about 44.5 feet at Helena, at which stage Helena discharges the greatest flood that passes Memphis, and that, if closing our front should raise Memphis 3 feet—an impossibility—Helena would discharge it on less than 48 feet, her present high-water reading.

In further confirmation of this, see Table V, discharge relations between Cairo, Memphis, and Helena. I have referred the Columbus discharge to the Cairo guage and take Fulton for Memphis. This shows that the maximum flood of 1882 at Cairo was 1,558,000 cubic feet per second, which gave the same discharge at Helena to 47.1 feet on that gauge, its highest reading.

Referring to Table VI, discharge relations between Cairo, Memphis, and Helena floods of 1892 and 1893—first, in 1892, the Cairo gauge to a maximum reading of 48.3 feet gave a discharge of 1,398,000 cubic feet per second. This gave on Memphis gauge 34.2 feet and a discharge of 1,288,000 cubic feet, which indicates an overflow of 110,000 cubic feet per second at that stage. Second, for 1893, the first (February) rise gave a maximum gauge at Cairo of 44.9 feet with a discharge of 1,363,000 cubic feet. This gave on Memphis gauge 32.2 feet and a discharge of 1,216,000 cubic feet, indicating an overflow (per second) of 147,000 cubic feet. The second flood of which observations were made at Cairo, Memphis, and Helena gave a maximum gauge at Cairo of 49.3 feet and a discharge of 1,507,000 cubic feet per second. This at Memphis gave a gauge of 34.6 feet and a discharge of 1,270,000 cubic feet, which indicates an overflow between Cairo and Memphis of 237,000 cubic feet per second. Helena, on the same day, at 43.7 feet on its gauge, gave a discharge of 1,229,000 cubic feet, 41,000 cubic feet per second less than Memphis, and continues to rise twelve days longer and reaches a stage of 47.7 feet on its gauge, with a discharge of 1,487,000 cubic feet, or 20,000 cubic feet only less than the maximum discharge of Cairo for the same flood, a quantity equal to that due to about 0.1 of a foot rise on the Helena gauge at that stage.

This shows that closing the St. Francis Basin can not raise the high-water mark at Helena; that Helena can discharge the greatest flood heretofore known at about 48 feet on its gauge, and therefore can not add anything whatever to the destructive force of a flood below Helena, in awe of which those citizens, taught by many sad calamities, stand.

What reason then can be assigned for longer leaving the St. Francis Basin open? All the reasons that have applied to closing any basin on the river apply to this, and certainly the citizens of the seven counties in Arkansas and three in Missouri, which form the Lower St. Francis Basin, by their patient endurance and heroic struggles, while waiting until the lower river was levied—as it was the announced policy of the Government to build from below upward—and by their prompt and efficient labors, unsurpassed in the history of levee building on that river, have earned for themselves the liberal recognition of your honorable commission.

Further, I might urge that the aid you have heretofore given them was an earnest of your future aid, a covenant with them, that you would continue that aid as liberally as Congressional appropriations would permit, all other interests in your care being equally well provided for. There was no suggestion in the liberal allotment you made them in 1892 that you would withhold further efficient aid until those impossible and unnecessary results claimed had been attained, or until "existing levees had produced their maximum effect in enlarging the discharge section."

The necessity for extending our levee to a point below Memphis is so urgent that I hope I may be pardoned if I again ask that our allotment out of the next appropriation be made $200,000 to secure that end.

I am, very respectfully, your obedient servant,

H. N. PHARR,

Chief Engineer Lower St. Francis Levee District.

TABLE NO. 1.

Date.	Cairo gauge.	Cairo difference.	Memphis gauge.	Memphis difference.	Helena gauge.	Helena difference.	Date.	Cairo gauge.	Cairo difference.	Memphis gauge.	Memphis difference.	Helena gauge.	Helena difference.
1890.							1890.						
Jan. 5	23.2	.....	17.8	.....	24.1	.....	Mar. 1	42.4	1.3	32.9	.5	42.4	.4
8	28.0	4.8	22.0	4.2	28.7	4.6	2	43.6	1.2	33.2	.3	42.6	.2
10	31.2	3.2	24.3	2.3	31.4	2.7	3	44.6	1.0	33.6	.4	42.8	.2
13	34.8	3.6	27.6	3.3	35.4	4.0	4	45.5	.9	33.8	.2	43.0	.2
14	34.6	.....	.....	.....	36.7	.....	5	46.3	.8	34.2	.4	43.2	.2
15	38.5	3.7	30.0	2.4	37.8	2.4	8	47.7	1.4	34.8	.6	43.8	.6
18	43.0	4.5	32.2	2.2	40.0	2.2	10	48.0	.3	35.2	.4	44.1	.3
20	43.7	.7	32.6	.4	40.8	.8	12	48.8	.8	35.5	.3	44.3	.2
23	43.5	.2	33.2	.6	41.6	.8	15	48.2	.6	35.5	.1	44.7	.4
28	42.2	1.3	33.3	.1	42.1	.5	18	48.2	.0	35.5	.0	45.4	.7
31	40.0	2.2	32.7	.6	42.0	.1	20	47.5	.7	35.6	.1	46.2	.8
Feb. 3	36.5	3.5	30.6	2.1	41.1	.9	23	46.7	.8	35.5	.1	47.5	1.3
5	34.6	1.9	29.1	1.5	40.0	1.1	25	46.6	.1	35.3	.2	47.7	.2
7	33.1	1.5	24.4	4.7	39.5	.5	26	46.7	.1	35.3	.0	47.7	.0
10	37.2	4.1	29.8	5.4	40.1	.6	28	47.1	.4	35.3	.0	47.6	.1
13	40.2	3.0	31.6	1.8	41.2	1.1	31	48.2	1.1	35.5	.2	47.4	.2
15	41.5	1.3	32.3	.7	41.6	.4	Apr. 3	48.6	.4	35.5	.0	47.1	.3
16	41.9	.4	32.5	.2	41.8	.2	6	48.6	.0	35.5	.0	47.0	.1
17	8.8	.....	32.6	.1	41.9	.1	8	47.7	.9	35.4	.1	47.1	.1
20	39.0	2.9	31.4	1.2	41.4	.5	10	45.8	1.9	35.2	.2	47.2	.1
23	.....	.....	.....	.....	40.6	.8	15	39.4	6.4	34.2	1.0	47.0	.2
24	34.4	4.6	30.1	1.3	40.8	.2	20	34.0	5.4	29.2	5.0	43.7	3.3
26	38.7	4.3	31.6	1.5	41.4	.6							
28	41.1	2.4	32.4	.8	42.0	.6							

TABLE NO. 2.

1891.							1891.						
Jan. 26	21.9	.....	16.2	.....	22.8	.....	Mar. 11	45.0	.5	34.7	.1	43.8	.1
28	23.2	1.3	17.8	1.6	25.6	2.8	14	44.6	.4	34.5	.2	44.0	.2
31	26.1	2.9	22.4	4.6	30.6	5.0	17	44.5	.1	34.2	.3	44.3	.3
Feb. 1	28.4	2.3	23.5	1.1	31.9	1.3	20	44.4	.1	34.0	.2	44.5	.2
3	31.7	3.3	25.6	2.1	34.3	2.4	23	44.1	.3	34.0	.0	44.7	.2
5	34.6	2.9	27.2	1.6	36.2	1.9	26	43.2	.9	33.7	.3	44.6	.1
8	37.5	2.9	29.0	1.8	38.2	2.0	29	42.0	1.2	33.8	.1	44.5	.1
10	38.8	1.3	29.9	.9	39.0	.8	30	41.9	.1	33.8	.0	44.4	.1
11	39.3	.5	30.4	.5	39.3	.3	31	42.3	.4	33.7	.1	44.3	.1
12	39.8	.5	30.6	.2	39.6	.3	Apr. 3	44.1	1.8	33.4	.3	44.0	.3
13	40.2	.4	31.0	.4	39.9	.3	6	44.8	.7	33.7	.3	44.0	.0
14	40.5	.3	31.1	.1	40.2	.3	9	44.2	.6	33.9	.2	44.0	.0
15	40.8	.3	31.2	.1	40.4	.2	12	43.3	.9	33.9	.0	43.9	.1
18	41.7	.9	32.0	.8	41.1	.7	15	43.1	.2	33.6	.3	43.8	.1
21	43.1	1.4	32.7	.7	41.7	.6	18	40.9	2.2	33.2	.4	43.5	.3
24	43.9	.8	33.0	.3	42.0	.3	21	38.8	2.1	32.1	.1	42.8	.7
27	45.2	1.3	33.3	.3	42.2	.2	24	36.1	2.7	30.0	2.1	41.6	1.2
Mar. 2	46.0	.8	33.8	.5	42.7	.5	27	34.2	1.9	27.8	2.2	39.8	1.8
5	46.2	.2	34.6	.8	43.3	.6	30	31.0	3.2	24.8	3.0	37.0	2.8
9	45.5	.7	34.6	.0	43.7	.4							

TABLE NO. 3.

Date.	Cairo gauge.	Cairo difference.	Memphis gauge.	Memphis difference.	Helena gauge.	Helena difference.	Memphis-Helena difference.	Cairo-Helena difference.
1892.								
Mar. 8	23.7	....	16.9	....	24.4	....	....	....
11	25.4	1.7	19.0	2.1	26.7	2.3	....	....
14	27.5	2.1	20.3	1.3	28.2	1.5	....	....
17	27.7	.2	20.0	.3	28.1	.1	....	....
20	26.4	1.3	19.3	.7	27.7	.4	....	....
21	....	....	19.2	.1	27.6	.1	....	....
22	25.5	.9	19.5	.3	28.0	.4	....	....
25	28.6	3.1	22.0	2.0	30.5	2.5	.0	.6
26	29.9	1.3	22.7	.7	31.4	.9	.2	.4
27	30.8	.9	23.4	.7	32.1	.7	.0	.2
28	31.5	.7	23.9	.5	32.8	.7	.2	.0
29	32.2	.7	24.5	.6	33.4	.6	.0	.1
30	32.8	.6	25.1	.6	34.1	.7	.1	.1
31	33.4	.6	25.6	.5	34.6	.5	.0	.1
Apr. 1	34.0	.6	26.1	.5	35.4	.8	.3	.2
2	34.7	.7	26.8	.7	36.2	.8	.1	.1
3	35.5	.8	27.8	1.0	37.3	1.1	.1	.3
4	36.6	1.1	28.9	1.1	38.3	1.0	.1	.1
5	38.5	1.9	29.9	1.0	39.1	.8	.2	1.1
6	40.2	1.7	30.6	.7	39.8	.7	.0	1.0
1892.								
Apr. 9	44.6	4.4	32.4	1.8	41.3	1.5	.3	2.9
12	45.8	1.2	33.4	1.0	42.3	1.0	.0	.2
15	45.2	.6	33.6	.2	42.7	.4	.2	....
18	44.6	.6	34.2	.6	43.3	.6	.0	....
20	43.9	.7	34.3	.1	43.5	.2	.1	....
23	46.5	2.6	34.2	.1	43.7	.2	.3	....
25	47.8	1.3	34.2	.0	44.0	.3	.3	....
26	48.1	.3	34.4	.2	44.1	.1	.1	....
27	48.2	.1	34.5	.1	44.2	.1	.0	....
28	48.3	.1	34.5	.0	44.4	.2	.2	....
29	48.1	.2	34.6	.1	45.5	.1	....	....
30	47.7	.4	34.6	.0	44.6	.1	....	....
May 3	45.7	2.0	34.4	.2	45.0	.4	....	....
6	40.3	5.4	33.8	.6	45.6	.6	....	....
7	38.3	2.0	33.6	.2	45.7	.1	....	....
8	36.1	1.2	33.0	.1	45.7	.0	....	....
9	36.6	.5	32.3	.7	45.5	.2	....	....
10	36.5	.1	31.8	.5	45.2	.3	....	....
13	....	....	31.2	.6	44.5	.7	....	....

TABLE NO. 4.

Date.	Cairo gauge.	Cairo difference.	Memphis gauge.	Memphis difference.	Helena gauge.	Helena difference.
1893.						
Jan. 21	8.6	.....	1.8	.....	3.0	.....
24	7.8	.8	2.6	.8	3.8	.8
27	5.4	2.4	2.7	.1	3.9	.1
30	6.4	1.0	3.4	.7	4.9	1.0
Feb. 2	7.0	.6	4.2	.8	6.2	1.3
5	17.2	10.2	12.6	8.4	16.2	11.0
8	23.2	6.0	16.3	3.7	22.1	4.9
11	24.3	1.1	17.8	1.5	24.4	2.3
14	27.6	3.3	22.4	4.6	30.2	5.8
17	34.2	6.6	27.4	5.0	35.7	5.5
20	40.1	5.9	30.0	2.6	38.3	2.6
23	43.1	3.0	31.6	1.6	40.0	1.7
26	44.5	1.4	32.6	1.0	40.9	.9
28	44.9*	.4	33.0*	.4	41.4	.5
Mar. 1	44.8	.1	32.9	.1	41.6	.2
3	43.2	1.6	32.9	.0	41.8*	.2
6	35.8	6.4	30.2	2.7	40.4	1.4
8	30.5	5.3	26.2	4.0	37.6	2.8
10	28.5†	2.0	24.0†	2.2	35.2	2.4
11	.....	.....	.....	.....	34.8†	.4
Apr. 11	24.1	.....	18.6	.....	27.4	.....
14	31.1	7.0	26.6	8.0	35.0	7.6
1893.						
Apr. 17	40.9	9.8	30.1	3.5	38.6	3.6
20	43.0	2.1	31.8	1.7	40.4	1.8
23	43.8	.8	32.4	.6	41.4	1.0
26	42.5	1.3	32.8	.4	41.8	.4
29	42.1	.4	33.2	.4	42.3	.5
May 1	44.9	2.8	33.4	.2	42.4	.1
4	47.7	2.8	34.0	.4	43.0	.6
7	49.2	1.5	34.8	.8	43.5	.5
8	49.3*	.1	34.9	.1	43.7	.2
9	49.3	.0	35.0	.1	43.8	.1
10	49.3	.0	35.0	.0	44.0	.2
11	49.2	.1	35.1	.1	44.2	.2
12	.....	.....	35.2*	.1	.....	.....
14	49.1	.1	35.2	.0	44.9	.7
17	47.7	1.4	35.0	.2	46.5	1.6
20	43.9	3.8	34.7	.3	47.8	1.3
21	.....	.....	.....	.....	47.9*	.2
23	37.5	6.4	33.2	1.5	47.9	.0
26	34.3†	3.2	31.1	2.1	46.3	1.6
27	.....	.....	31.0	.1	45.8	.5
30	.....	.....	.....	.....	45.5	.3
June 3	.....	.....	.....	.....	45.0	.5

* Interpolated. † Error.

TABLE V.

Date.	Cairo.				Helena.				Difference Cairo and Helena discharge.
	Gauge.	Discharge.	Difference gauge.	Difference discharge.	Gauge.	Discharge.	Difference gauge.	Difference discharge.	
1882.									
m. 17	43.2	1,317	1.0	.....	41.7	1,088	.....	.....	229
19	44.6	1,349	1.4	32	42.2	1,174	.5	86	175
27	47.4	1,469	2.8	120	43.8	1,287	1.6	113	182
eb. 3	47.7	1,348	.3	121	44.8	1,231	1.0	56	117
6	47.3	1,322	.4	26	46.0	1,317	1.2	86	5
18	45.8	1,272	1.7	50	.....	.....	.....	.....	.....
22	49.5	1,603	3.7	331	45.5	1,230	.....	.....	373
28	50.8	1,558	1.5	45	45.7	1,282	.2	52	276
ar. 1	51.0	1,502	.2	56	46.3	1,282	.6	0	220
3	50.3	1,518	.7	16	47.0	1,506	.7	224	12
4	49.9	.....	.4	.....	47.1	1,558	.....	.....	.....
6	49.2	1,430	.7	88	46.4	1,513	.6	7	83
7	48.5	1,403	.7	27	46.2	1,412	.2	101	9
9	47.9	.....	.6	.....	46.5	1,562	.3	150	.....
10	47.7	1,324	.2	79	46.4	1,513	.1	49	189
11	47.5	1,313	.2	11	46.2	1,412	.2	101	99
13	47.8	1,361	.3	48	46.0	1,434	.2	22	73
23	43.6	1,053	4.2	302	44.9	1,378	1.1	56	325

TABLE VI.

Date.	Columbus—Cairo time.				Fulton—Cairo time.				Difference in discharge Columbus and Fulton.
	Gauge reading.	Difference.	Discharge.	Difference.	Gauge reading.	Difference.	Discharge.	Difference.	
1892.									
pr. 16	41.0	.....	1,163	.....	33.3	.....	1,382	.....	219
26	43.0	2.0	1,364	201	34.2	0.9	1,226	150	138
27	43.0	0.0	1,384	20	34.2	0.0	1,245	19	139
28	43.1	0.1	1,398	14	.....	.....	.....	.....	.....
29	43.1	0.0	1,352	46	34.2	0.0	1,288	43	64
30	42.9	0.2	1,401	49	34.2	0.0	1,283	5	118

Gauge relations, 1893.

Date.	Cairo—Cairo time.				Fulton—Cairo time.					Helena—Cairo time.				
	Gauge.	Discharge.	Difference gauge.	Difference discharge.	Gauge.	Discharge.	Difference gauge.	Difference discharge.	Difference Cairo and Fulton discharge.	Gauge.	Discharge.	Difference gauge.	Difference discharge.	Difference Cairo and Helena discharge.
1893.														
May 5	48.4	1,445	.....	.....	33.9	1,225	.....	.....	220	43.1	1,190	.....	.....	255
6	48.9	1,484	0.5	39	*34.2	1,245	0.3	20	239	43.3	1,210	0.2	20	274
7	49.2	1,507	0.3	23	34.4	†1,340	0.2	95	167	43.5	1,197	0.2	13	310
8	49.3	1,499	0.1	8	34.5	1,264	0.1	76	235	43.7	1,229	0.2	32	270
10	49.3	1,434	0.0	65	34.6	1,270	0.1	6	164	44.0	1,253	.....	.....	.....
13	49.2	1,523	0.1	89	34.6	1,208	0.0	62	315	44.6	1,299	0.9	70	224
14	.....	.....	.....	.....	.....	.....	.....	.....	.....	44.9	132	.....	.....	.....
15	49.0	1,472	0.2	51	34.5	.....	.....	.....	.....	45.2	1,343	0.6	44	129
17	47.7	1,403	1.3	69	34.2	.....	.....	.....	.....	46.5	1,421	1.3	78	.....
20	43.9	1,144	3.8	259	33.1	1,098	.....	.....	46	47.7	1,501	2.5	158	357
21	41.8	.....	.....	.....	32.4	.....	.....	.....	.....	47.9	1,555	0.2	54	.....
22	39.6	.....	.....	.....	31.4	.....	.....	.....	.....	47.8	1,527	0.1	28	.....
25	34.7	.....	.....	.....	28.5	.....	.....	.....	.....	47.0	1,449	0.8	78	.....
26	34.3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
27	.....	.....	.....	.....	28.3	.....	.....	.....	.....	45.9	1,385	1.1	64	.....
28	.....	.....	.....	.....	.....	.....	.....	.....	.....	45.8	1,387	0.1	2	.....
29	.....	.....	.....	.....	.....	.....	.....	.....	.....	45.7	1,386	0.1	1	.....
June 1	.....	.....	.....	.....	.....	.....	.....	.....	.....	45.3	1,344	0.4	42	.....

* Interpolated. † Error.

I submit to you the opinion of Maj. T. G. Dabney, chief engineer of the Yazoo (Miss.) levee district, contained in a paper on levee building read before the United States board of district officers of the Lower Mississippi River and dated July 25, 1894. He says:

And yet I have hopes that the unseen and unknown influences that affect the regimen of the Mississippi River in ways that can not be accounted for by reasoning from any known premises may here operate to modify the results as indicated above [in reference to Captain Townsend's ideas]. The hope thus expressed is based upon these reflections, to wit: The Yazoo Basin, as a hydrographic feature of the Mississippi Delta, bears an exact analogy to the St. Francis Basin. The complete closure of the Yazoo Basin does not appear to have produced the effect upon the high-water plane at Vicksburg which is ascribed to Helena as the anticipated effect of closing the St. Francis front. On the contrary, I believe it is the opinion of the Mississippi River Commission that the high water at Vicksburg has been permanently lowered by leveeing the Yazoo front. If this is true why should it not be similarly lowered at Helena by leveeing the St. Francis front?

Again, in 1886, when the river had come to a stand three days before at Memphis, and was then rising at the rate of three-tenths a day at Helena, the St. Francis wave suddenly showed itself, causing a rise of 2.6 feet in three days, the middle one of these three days giving a rise of 1.2 feet in one day. Is it not a fair inference that the water which contributed to this rapid rise at that critical stage, if confined to the main channel, would have extended itself over a greater length of time in passing Helena, and consequently would have attained a lower maximum on that gauge?

The gentleman seems to have changed his mind within the past three years, and from his observations of one overflow (1897) has formed an opinion, upon circumstances which did not exist and never will exist, that Helena might go 2 feet higher than 1897 and 5 or 6 feet higher than 1893.

I further submit a copy of my predecessor's letter to Colonel Gillespie, with hydrographs of the late flood of 1897 accompanying, by which he again shows proof of his contention and of which there can be no doubt.

I shall be glad of an opportunity to explain these hydrographs and present other facts in support of our position while with you along our front.

Our hope is—with the assistance we think we are entitled to receive from the Government, and which we expect—to close this basin from

Point Pleasant to the mouth of the St. Francis River before another disastrous overflow, and in not more than three years. When the work now under construction is completed we will have 95 miles of practically new levee to build from chute 38 to mouth of St. Francis River, which I estimate will cost $1,012,000, and enlarge to 2 feet above the last high water (1897) all of our levee from the Missouri-Arkansas State line to Pecan Point—a distance of 63 miles—which will cost $265,000; or a total of $1,277,000 will give us a levee which we may expect to hold even against a '97 high water, and, although this district has anticipated its revenues to a great extent, we hope to be able to do $277,000 of this work, asking the Government to come to our aid with $1,000,000.

The St. Francis levee district of Missouri, 47 miles in length, should be raised to a grade 2 feet above the 1897 high water, which I roughly estimate will cost $160,000, and of which they may be expected to do $60,000, asking the Government to come to their aid with $100,000. This will give us the finest country in the world and will provide homes in this rich alluvial basin for thousands of souls.

I would like to submit several papers in connection with this testimony and for your consideration.

(The papers were marked "Exhibits R, S, T," respectively, and follow in their order.)

EXHIBIT R.

OFFICE OF ST. FRANCIS LEVEE BOARD,
West Memphis, Ark., June 18, 1897.

Col. G. L. GILLESPIE,
Corps of Engineers, United States Army,
President Mississippi River Commission, Army Building, New York.

DEAR SIR: In addition to what I have heretofore said as to the effect of closing the St. Francis front, I wish to submit a table showing the distances between gauges, the difference of zero elevation of same, and slope per mile between gauges. This table shows distinctly the Cairo pool to be more than 18 feet deep and to extend from Chester to New Madrid.

The Helena pool is also distinctly shown, and the uniformity of slope between New Madrid and Mhoon's will attract your attention. The White River Sun Flower low-water plane produced would pass about 7 feet above zero of the Helena gauge, and intersect the low-water plane about Mhoon's. This pool is small compared to the Cairo Pool, and fills up faster; hence we see Helena rising more rapidly than Cairo from 10 feet to 28 feet on the Cairo gauge. At about that stage, the Helena pool appears to have filled, and begins to fill the larger pool, extending to Greenville.

As this pool fills, the slope above is reduced, the discharge slackened, and the Helena gauge raised somewhat. How much is due to this "engorgement," as it has been called, we may not get at with a great deal of accuracy, but we may reason upon it in this way: With the St. Francis front closed, giving possibly 39 feet on the Memphis gauge, add 7 feet for Helena Pool, making 46 feet, and 3 feet for engorgement below, and we have 49 feet on the Helena gauge. To relieve that engorgement it is necessary to establish a normal slope of 0.4 foot between Helena and Vicksburg, to do that it is necessary to reduce the 293 miles between these points 53 miles, or to 240 miles; this can be done at much less expense than enlarging the levees, the necessity for which it would obviate.

Here I conclude all I wish to say upon the subject in hand, as a civil engineer, repeating no more than this: The closing of the St. Francis front is a necessity to the levee system below, but, as a citizen of that territory, suffering myself and sympathizing with my people in their sufferings, I ask, Why not close that basin?

The lives of our people are as dear to you as the same number of lives anywhere in the valley. The protection of their property commends itself to you as much as the same protection to others. There were more lives lost and more property destroyed, more homes desolated, and farms devastated in that basin by the late flood than in any other—perhaps in all other districts on the river. The benefits commerce will derive from that work will be equal to that derived from any work of the same extent and kind. Thus we see that in all reason and conscience that front should be closed.

It will take to repair and enlarge the Missouri division $100,000, and to repair and enlarge the present levee and build the 109 miles of new work in the Arkansas division $1,300,000.

We ask you to allot $150,000 to the Missouri division and $750,000 to the Arkansas division. The Arkansas district will supplement your allotment of $750,000 by such

sum as will complete the work, including contingent expenses, about $600,000, and complete the whole before another flood.

I submit to your honorable board that this is not an unreasonable request. If we review the history of recent events along this line, we will see that the appropriation of 1892 was about $10,000,000, $6,000,000 going to leeves. This front was allotted but $264,000 to assist in building 224 miles of new levee, while millions went below to enlarge levees already built to established grades and cross sections. Of this we did not complain, but believed it wise, especially when we were told that those sums would place that whole system of levees in a satisfactory condition, and that you would doubtless make liberal allotments to our front next time. In fact, we were assured that we were to be the principal beneficiaries. Of course your honorable board was in no way responsible for this statement. I only mention it to show you what was going on among the laity.

Out of the appropriation for 1897 the St. Francis front, with 30 miles of defective levee and 109 miles of unprotected front, was allotted something more than $16,000, while very large sums went to levees already built.

Another fact in the history of this work to which I wish to call your attention is that of the $250,000 so generously appropriated during the late flood to assist in maintaining levees the St. Francis front was offered the sum of $86 upon impossible conditions, and it had to be declined. Thus we see that you have allotted to this great interest but $280,000 in round numbers. Taking as a valuation of that district the low estimate of $20,000,000, the sum of allotment amounts to 1¼ per cent only and to the whole line $1,200 per mile. You will pardon us, I hope, if we speak frankly at this time. We have waited and suffered for the last fifteen years, while the Government through your hands has aided liberally in the contruction of levees elsewhere. Can it be contended that all other districts must be protected beyond a possibility of danger before the citizens of St. Francis Basin can expect their due proportion of aid from you? Your honorable board will not entertain an idea of such gross injustice. We are as much entitled to the care and protection of the Government as any equal number of citizens in any district in the valley, and we can no longer subscribe to the theory that all other districts must be placed in a position of absolute safety before we can be in any measure protected.

The levees below broke—they will doubtless break again—but, considering the magnitude of the late flood, the levees were held beyond all reasonable expectations, and the fact that the levee system can be, and therefore will be, maintained was fully demonstrated. What do those levees need now more than to close those breaks? If they could be held against the 1897 flood they can be held against any flood, for the full effect of closing the St. Francis Front has been felt, to which was added the accumulated flood of that basin.

Now, Mr. President, in view of these facts and our present condition, I respectfully submit that the time is ripe for your honorable board to proceed to close the St. Francis Front by making to that front the allotments for which we ask.

Very respectfully, your obedient servant,

H. N. PHARR,
Chief Engineer Lower St. Francis Front.

Distances between gauges, differences of zero elevation of same, and slope per mile.

	Miles.	Difference 0 of gauge.	Fall per mile.
St. Louis to Chester	72.4	38.93	0.538
Chester to Grays Point	63.1	40.02	0.634
Grays Point to Cairo	45.0	30.44	0.676
Cairo to Belmont	21.3	3.70	0.173
Belmont to New Madrid	49.0	11.42	0.233
New Madrid to Cottonwood Point	52.7	25.10	0.476
Cottonwood Point to Fulton	52.4	22.07	0.421
Fulton to Memphis	54.6	24.58	0.450
Memphis to Mhoons	47.3	22.49	0.475
Mhoons to Helena	29.2	19.50	0.667
Helena to Sun Flower	46.2	14.90	0.322
Sun Flower to mouth White River	40.5	18.35	0.453
Mouth White River to Arkansas City	45.1	12.29	0.272
Arkansas City to Greenville	40.0	8.44	0.211
Greenville to Lake Providence	64.0	18.38	0.308
Lake Providence to Vicksburg	57.0	23.59	0.414
Vicksburg to St. Joseph	49.0	13.30	0.271
St. Joseph to Natchez	52.0	15.86	0.305
Natchez to Red River Landing	65.0	13.04	0.201
Red River Landing to Bayou Sara	34.5	—.10	0.000
Bayou Sara to Plaquemine	54.3	2.89	0.005

EXHIBIT S.

OFFICE CHIEF ENGINEER, ST. FRANCIS LEVEE BOARD,
West Memphis, Ark., May 26, 1897.

.. GILLESPIE,
of Engineers, United States Army,
President Mississippi River Commission, Army Building, New York City.

EL: In an effort to comply with your request of the 21st ult., I have the submit for the inspection of your honorable board a series of profiles of Helena. I find that I cannot do justice to the subject in hand or treat it isfaction with less than an exhaustive comparison of the relations of these You will observe that the plates are numbered from 0 to 8, inclusive.

ttention first to Plate O. Profiles of Cairo, New Madrid, Cottonwood Point, , and Helena wave of 1896 which was strictly within banks from start to t will be observed that from 19 to 26 the Helena curve lies closely with that at 26 it begins to diverge and continues to do so at an increasing ratio until lts on March 27, when Helena is 1.5 feet below. There a sharp decline of iro gives but 0.2 at Helena, putting Helena 0.8 above Cairo. Thence to the he second wave, the rate at Cairo exceeds that at Helena and puts Cairo above. In the last rise of 8.5 Cairo gained 1.5 on Helena. Had the wave tinuous Cairo would have gone to 41 and Helena would have been 3 below. vergence of the two gauges is plainly shown on plate 1. Gauges of 1897, hen Cairo is 45 Helena is 4 below, at 41, while Memphis had not reached the ine, and no perceptible effect can be ascribed to outflow up to that stage. inuous rise this divergence of gauges invariably takes place somewhere 24 and 36. The more rapid the rise, the sooner it begins; the less rapid, the is delayed.

ase of this appears to be that a rapid rise gives a greater slope, a greater a greater elongation, and a greater depression. A less rapid rise diminishes ses and effects, but no continuous wave, whatever its rate of rise at Cairo, the Cairo gauge to Helena if unmolested by extraneous influences. Short ming in quick succession can do it, provided they are repeated often three or four times—but these need not be noticed, as they seldom reach rk further than to suggest the error which necessarily follows from an effort ish gauge relations from their gauge readings to be applied to maximum hich can not be produced in such quick succession. In a former paper I 1 how these low but quickly succeeding waves destroyed normal gauge

particular attention to the profiles of the New Madrid, Cottonwood Point, nd Memphis gauges, Plate O, and respectfully submit that the New Madrid overn the gauges from that point to Mhoons much more closely than the ge, and gives results between these points as shown by these gauge curves. lainly shown again by the profiles of these guages on Plate I. The uniform which these curves hold to the New Madrid curve until that relation is l by extraneous influences is interesting. Beginning on the 23d of Febru- o time, New Madrid is 26.4′. Memphis is 24.4′, or 2′ below. Thence for ys, to the 10th of March, the ratio of rise between these two curves is so ity that New Madrid has gained but 0.6′ on Memphis; there, New Madrid e sensibly the fall at Cairo and reduces its 2.6′ lead to 1.5′ on the 14th. The days they rose together 0.5′, at which point Memphis yielded to the outflow doned New Madrid.

mination of plate 2 will show at a glance how far the flood of 1897 exceeded great floods—as far as our records go—in magnitude, while it lacked nearly f reaching at Cairo the highest known water, 52.17, of 1883. Yet the volume far exceeded that of 1883, or any other year, the flood of 1883 remaining six- a half days above 48 inches on the gauge, while the 1897 flood remained forty ve that line; or the flood of 1883 was to the flood of 1897 as 16½ is to 40. In to the maximum flood that passed Cairo, 1 foot of water fell along the whole . Francis front while the crest of the wave was passing, which was easily 2 on the river, or a gauge reading at Cairo of 53.6. See meteorological map see, hereto attached.

flood of 1897 was probably the greatest that any man living to-day will it is sufficient for the near future to show what would have been its high- e along the St. Francis front had that levee been completed and maintained. uld have been the gauge reading at Helena, and the probable results in the ow. The curves of plate 0 show so conclusively the gauge relations that ng the St. Francis front were that front closed, that it is unnecessary to further, more than to say that plate 0 presents the gauge curves of a maxi- rained flood with an average degree of adverse accident.

re no reasons why, if similarly restrained, a flood of 52 at Cairo should give ge relations than here shown. Plate 1 shows very much the same gauge

relations between the shoal gauges as seen on plate 0 until New Madrid reaches 38.4 feet when Memphis was 37.1 feet, at which point Memphis went off; the outflow being so great as to take off all further rise at Cairo and to force the river down slowly at Memphis. Hence we see that the overflow exceeded in quantity the amount of water that passed Cairo above the 49 foot mark or more than 2.6 feet of the crest of the wave, which equals about 5 per cent of the fluctuations, about 10 per cent of the volume, and about 20 per cent of the flow. Had this front been closed, I suggest that the Memphis curve would have followed the broken line indicated and reached 38 feet, possibly 38.5 feet. It could not have gone higher.

I wish now to ask your careful attention to the curve of the Mhoon gauge on this plate (1). You will observe how close and parallel to the New Madrid curve it lies, but below it to 38 feet. There the New Madrid gauge, being more sensitive to the Cairo gauge, drops below Mhoon's, but at once begins to converge toward and reaches it at 40.2 feet. There we see the unmistakable evidence of the superiority of the New Madrid curve compared to that of Mhoon's. But just at that time (40.2 feet), Mhoon's began to feel the return flow of the St. Francis, which gave 1.8 feet rise to that gauge. How much higher the St. Francis flood would have forced the Mhoon gauge had the Flower Lake and other levees in the vicinity held, we can not know accurately.

We may reason from the facts that the water in the lower part of the St. Francis basin was estimated to be 4.1 feet above all former watermarks, while near Flower Lake, before the break, I am informed it was 3.9 feet. The further rise at Mhoons and at Helena could not have been great. But this appears plain, had there been no return flow from the St. Francis Basin, Mhoons would have, at 40.2 feet, resumed its place with and below New Madrid, and its position above indicates the volume and duration of the return flow.

Examining the Helena curve on this plate (1), we see that it was, on the 23d of February (Cairo time), 32.9 feet on the gauge and 0.4 feet above Cairo. That it crossed below Cairo at 35.8 feet and took in increasing ratio of divergence from that curve. When at 40 feet Cairo was 43.5 feet. When at 42 feet Memphis was at 33 feet, the outflow line, and Cairo at 46.4 feet or 4.2 feet above Helena. Up to this point there was no waste such as to materially affect the Helena gauge. The 1897 flood was restrained at this stage (46.4 feet) by levees for 20 miles below Fulton, where 33 is danger line. When Helena was at 44 feet Cairo was 48.5 feet. This is the relation of the two gauges for all continuous floods up to the point of extraneous influence. Helena felt but slightly the decline of the 12th and 13th of March at Cairo, which brought the Cairo curve too near to that of Helena to sustain it; hence Helena reduced its rate of rise and went off. Just then it began to receive the St. Francis flood, which forced it up 2 above the normal stage, due to the Cairo gauge. As to how much higher it would have risen if breaks had not occurred see conclusions as to Mhoons gauge.

As to why the St. Francis flood gives this final abnormal maximum flood to the Helena gauge see a former paper submitted to your honorable board.

Referring to plate 1A, gauge curves of Cairo, Helena, Arkansas City, and Vicksburg flood of 1893, it will be observed that a secondary wave gave Cairo on the 15th of April 36, and in eight days carried that gauge to 43.8. Being spent at that stage, the river fell to 41.8, at which point the approach of the maximum of that year was felt and the rise continued to 49.3 feet. Not being sustained as the late flood was, it, after nine days of maximum reading, fell rapidly.

The Helena curve begins on the same date (April 15) at 36.4 — 0.4 feet above Cairo, with an increasing ratio of divergence from that curve. At 38 Cairo was 40, 2 feet above. At this stage the river was strictly within banks. This again proves my contention, heretofore set up,—that no flood, however great, can transmit its gauge reading at Cairo to Helena, if constrained to the channel. If the contrary should be asserted, then I ask at what point between 40 and 52 Cairo gauge will the Helena curve be reversed? And why? Comparing Helena on this plate and same on plate 1, we observe that the rate of rise at Cairo has much to do with the outflow into the St. Francis Basin.

The flood of 1897 rose 16 feet in fourteen days. The increased inclination of flood plane thus produced gave such a velocity of current in the channel as to counteract very much lateral currents and prevent that congestion due to their existence. This is plainly seen in both the Memphis and Helena curves of 1897. The difference between the Helena curves of 1897 and 1893 is not due wholly to a difference of velocity by any means, for in 1893 the Point Pleasant-Bear Bayou levee was not built. That levee restrains a large volume of water to the channel, which affected materially both the Memphis and Helena curves. I inject this as a matter of interest rather than importance.

I have shown by curves of 1896, of Cairo, New Madrid, Cottonwood Point, Fulton, Memphis, and Helena—plate 0—the remarkable uniformity of relations existing between these gauges for a restrained flood, and contend that these relations would

exist for all such floods; also, that the New Madrid curve governs all gauges below to Mhoons or all shoal gauges; also, that Helena takes an increasing ratio of divergence from and below the Cairo gauge up to the line of outflow, and contend that there are no reasons why the same relations should not continue under the same conditions. If this be true, closing the St. Francis front can not raise the water at Helena as high as at Cairo by from 2 to 4 feet, depending upon the rapidity of the rise at Cairo. A rapid rise will raise Helena less than a less rapid rise of equal height; also, that restrained floods are thereby very much reduced in duration. Therefore, for the protection of the levees below, the St. Francis front must be closed.

Plate 1 confirms my contention as to the relations existing between the Cairo and Helena curves. It also demonstrates the fact that the New Madrid curve governs those of the other shoal gauges, and shows the probable Memphis curve for 1897 (had the front been closed) at 38.5, as indicated.

Plate 1A shows the curves of the pool gauges for 1893 when the St. Francis front was wholly open and the other large basins closed, or practically closed. It shows distinctly the effect upon the Helena gauge of the vast outflow along the upper part of this front, which has since been closed, also the effect of the floods of the White and Arkansas rivers, which came in or near the crest of that wave on the Arkansas City and Vicksburg curves, raising them somewhat and extending them very much. I have indicated by a broken line the probable Helena curve for that year had this front been closed.

Plate 2 shows the Cairo gauge curves for four maximum floods. It will be observed how much 1897 exceeds all others.

Plate 3 shows the same for New Madrid. It will again be noticed how much 1897 exceeds the others.

Plate 4 shows the same for Fulton. It will be observed that the Fulton curves conform closely to those of Memphis, showing the same outflow and to about the same extent.

Plate 5 gives the gauge curves for Memphis for four maximum waves, and indicates the Memphis curve for the late flood with this front closed.

Plate 6 gives the same for Helena. The return flow is plainly to be seen in each curve, giving to Helena at all times its highest water. This return flow coming out at an elevation much higher than that due to the stage of water in the river—having been retarded in its progress through 200 miles by the innumerable objects in that basin that obstructed its flow and caused it to accumulate or dam up—raises the water on the Helena gauge 3 or 4 feet, increases the velocity, and overtakes the the receding flood in the river and sustains it for weeks after it should be in the Gulf of Mexico against that system of levee, increasing the probability of disaster about in proportion to the square of the time in days.

An idea of the quantity of support given the flood in the lower river may be had by remembering that the area of the St. Francis Basin is about 5,000 square miles, and that the average depth is about 8 feet. This is equal to a stream 1 mile wide, 40 feet deep, and 1,000 miles long. Flowing at the rate of 1,000,000 cubic feet per second, or an average mean velocity of 4.5 feet per second, it would take fourteen and one-fourth days to run out. This is very close to what in fact occurs. This basin, open, stands above the whole levee system below, a demon with Pandora's box in its hands.

Plate 7 shows gauge relations of Cairo-Helena and New Madrid-Memphis, repeated here to avoid the confusion incident to several lines grouped together.

Plate 8 shows the curves of the increments of the daily variations of the several gauges. The signs of the increments were observed in platting with the result as shown.

If I am again asked why the outflow does not reduce the flood in the river equal to the rise given by its return flow—i. e., why one does not compensate for the other—my reply is that the outflow reduces the depth of water in the river, thereby reducing its velocity; also that the lateral currents induced by the outflow further impede the velocity. Suppose 350,000 feet per second outflow, equal to one-fifth of the whole volume, reduces the mean velocity but one-fourth. That will reduce the discharge one-fourth and sustain the flood height so far as to compensate finally for the outflow. Hence we see gauge curves do not indicate outflow except when in near proximity. Therefore, when the basin has been filled and its flood reaches the mouth of the St. Francis it does not find that its coming has been discounted. Hence it is able to give undue elevation to the Helena gauge.

As a final argument on the proposition that closing the St. Francis Basin can not raise the water at Helena under normal conditions much above its maximum reading previous to 1897, I here submit in tabular form the 0 elevation of the several gauges from Cairo south, the difference in elevation, the distance in miles, and the difference per mile, which shows that the rate of slope per mile increases from Cairo to Helena largely, and with much uniformity (and that if the Cottonwood Point—New Madrid slope—were produced to Cairo it would pass that gauge 18.98 above. This shows

the Cairo Pool). It is on this series of planes, increasing rapidly in inclination sou ward, that the flood is precipitated, and the velocities and discharges must be some relation to those inclinations, other conditions being equal. And until it shown that conditions are so unequal as to compensate for the difference in inclin tion of planes, we must insist that Helena will discharge more water than Cairo the same gauge reading. If that be correct, the Helena gauge can not equal th Cairo gauge for the same flood, but, as we have heretofore shown, must be from 2 4 feet below.

While we have this table before us, let us see why there is such an accumulatio of water in the lower river and why does it loiter there so long. The table show that from Helena south the low-water planes are much less inclined, the averag being 0.22 foot per mile, or stopping at Baton Rouge in our comparison, 0.28 foot pe mile, while from Cairo to Helena it is 0.42 foot. The high-water line approaches uniform plane, but does not increase average slope.

It is plain that there is not slope enough between Helena and Vicksburg wher the depth of channel does not compensate for the want of it. From Memphis t Helena the slope is 0.547 foot per mile. From Helena to Vicksburg it is 0.327 foot or a decrease of slope of 62.41 feet in a distance of 292.8 miles. This want of slop should be remedied. The remedy is to cut off three bends of the river, reducing it length more than 40 miles, thereby increasing the slope and reducing the high-wat line along that reach of the river so far as to make their present levees sufficient fo any flood. This increased velocity will remove the bars and improve the navigab conditions of the channel.

It will doubtless require a large sum of money to enlarge the levees on each sid along that reach to such a grade line as the late flood has indicated.

These cut-offs and the necessary bank protections below each can be done prob bly for one-fourth the cost necessary to enlarge the levees, a million dollars be save and a vast amount of apprehension eliminated.

The late flood has been surpassed at Cairo by only two of record. The gauge of 18 read 0.2 foot and that of 1883 0.57 foot higher, while no flood of record was sustained f such length of time or extent at that point. The excessive amount of rainfall alon the Cairo-Helena reach and adjacent territory during the month of March, as the cre of the flood was approaching and passing, added very largely to the vast volume water. That rainfall averaged about 12 inches over the entire State of Tennesse being more than 10 inches at Memphis. It was this rainfall coming out of the Te nessee and Cumberland, close upon the 66 feet Cincinnati gauge of the Ohio, whi checked the fall of the Ohio flood on the Cairo gauge and gave that gauge its maximu wave of 51.6. The rainfall, above noticed, adding largely, as said, to the volume water below Cairo. The restraint offered by the levees along the 66.5 miles, ov which more than 95 per cent of the outflow into the St. Francis Basin had heretofo passed (see report of M. R. C. of 1890), together with the rainfall, caused an elevati of the high-water line which appears to have culminated, near Luxora, Ark., in a wa 4 feet above all former floods. Further instrumental examinations will show mo accurately how it passed off.

I wish to call attention particularly to this—95 per cent of the outflow into th St. Francis Basin having been restrained by levees and the result exaggerated b rain seen, we know that the restraint of the 5 per cent of former outflows, not ye confined to the river, can not add much to the elevation of the flood line as estab lished by the 1897 wave.

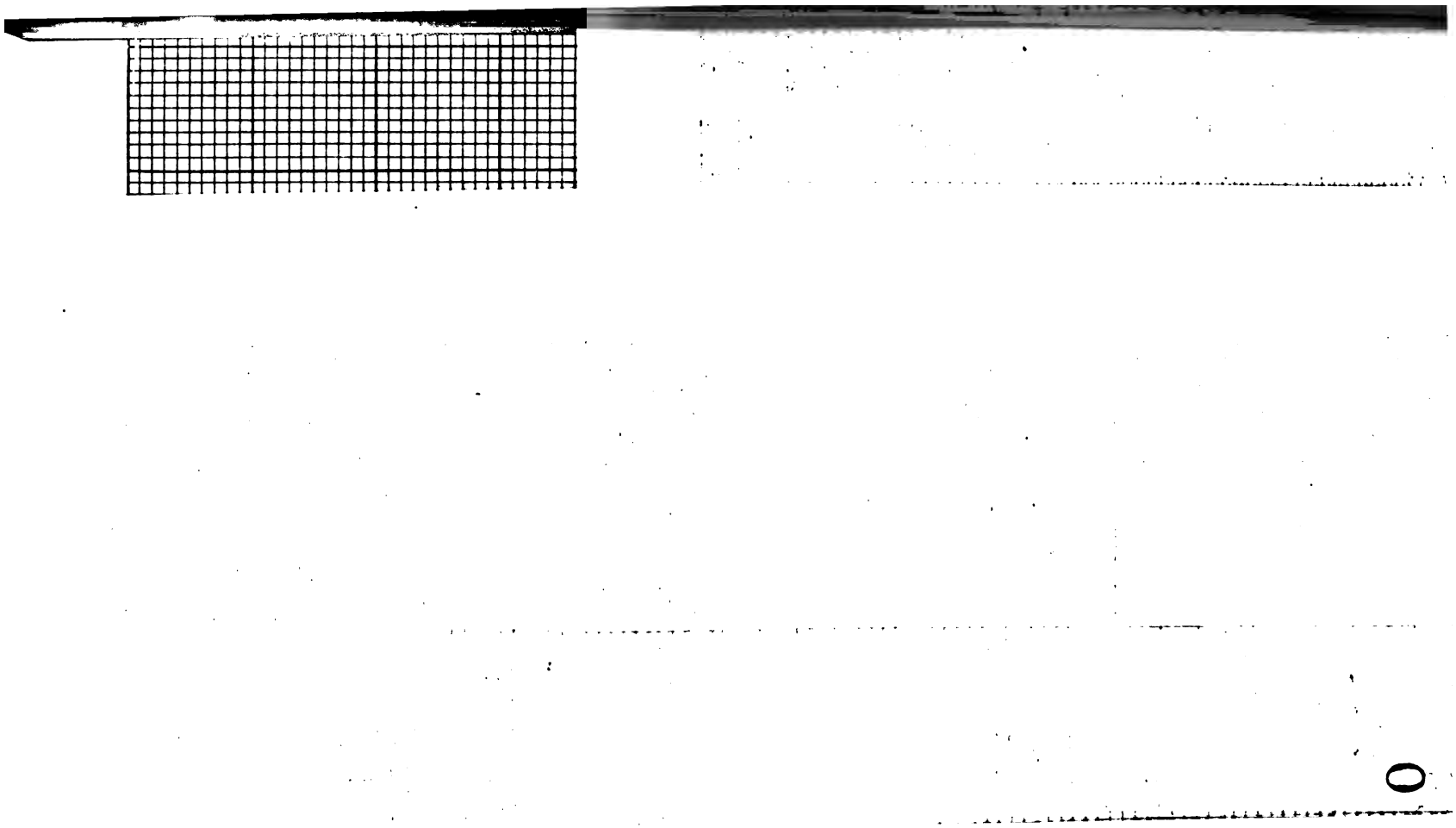
The velocity of current during the late flood, especially during the rising stage was much greater than heretofore at the same stage. Further, there was a mor general movement between banks—a much greater mean velocity—than heretofor observed. The rapid rise and great elevation it attained, the inclination of slope and volume of water accounts for this.

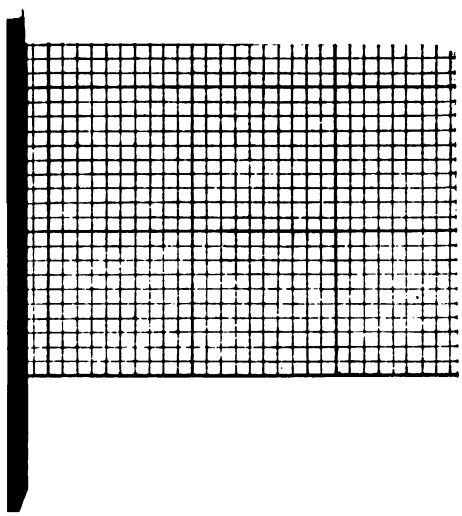
I have few suggestions to make as to levee construction. The specifications unde which we are now building gives us a good levee and is costing us all we are abl to pay. In the future other plans and specifications will doubtless be adopted, bu any material change in specifications will add largely to the cost. Without suc change, in locating, angles should be avoided and curves made so flat as to admit o a railroad track being operated on it. This would lead to a rock ballast of th crown, and next to a rock revetment of the slopes, which would add very much to th permanency of levees. But at present we want levees—a defensive line from behin which we can check the progress of the enemy while we are perfecting this or build ing another of greater strength.

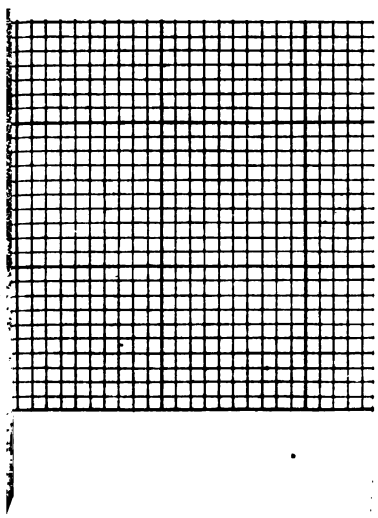
Respectfully submitted.

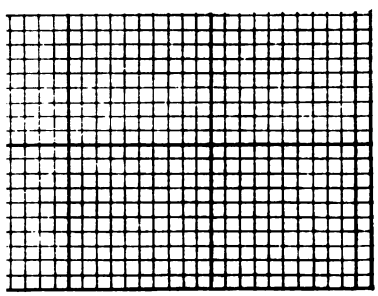
H. N. PHARR,
Chief Engineer, Lower St. Francis Front.

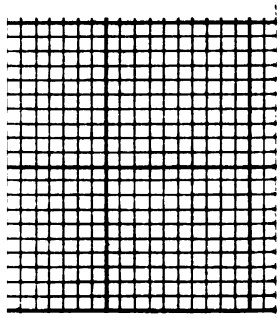
Q. I understand from your statement, if there were no levees and th water was allowed to overflow and go into the St. Francis Basin, tha with the obstructions now existing there it would take fifteen days fo

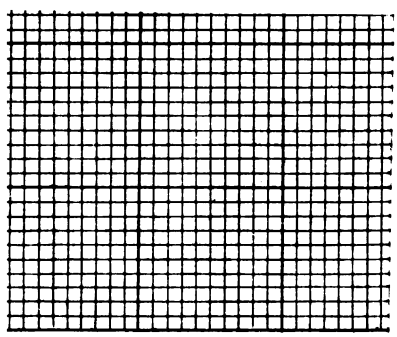












the water to run from Cairo down to Helena, whereas by the Mississippi it would take but three days?—A. No, sir; not exactly.

Q. Was not that substantially your statement?—A. No, sir. My statement was that for the water to run through the basin, through the cane brakes and obstructions that are there, it takes about eight to fifteen days to run from Cairo to Helena.

Q. And the same water, if it was kept out of the basin, and in the Mississippi River, would take how long?—A. About four days, from Cairo to Helena.

Q. Is it not a fact that at Cairo the floods of 1882 and 1883 were higher than the flood of 1897?—A. Yes, sir; both were higher at Cairo than the flood of 1897.

Q. Is it not a fact that at Memphis and at Helena the 1897 flood was much higher than the floods of 1882 and 1883?—A. Yes, sir.

Q. At Memphis, the flood of 1882 was 35, in 1883 it was 34.8, and in 1897 it was 37.1?—A. That is right.

Q. And is it not a fact that in 1882 it was 47.2 at Helena and in 1883 46.9, while in 1897 it was 51.5?—A. I think so.

Q. Now, how do you account for the fact that the stage of water at Cairo in 1882 and 1883 was higher than in 1897, and in 1897, with a lower stage at Cairo, it was higher at Helena and Memphis? Do you not think the construction of levees had something to do with that, the construction of levees along the St. Francis Basin?—A. That is what all engineers agree on, that leveeing the St. Francis Basin will raise the water at Memphis. That is granted to start with.

Q. And at Helena, too, will it not?—A. No, sir; it will not.

Q. That is, of course, the usual——A. Yes, sir; but the district was not leveed.

Q. I mean if the St. Francis Basin is entirely leveed?—A. Oh, when it is entirely closed it will lower the high-water mark at Helena; yes, sir.

Q. But as it was last spring, was it not a fact that it was then considerably higher at Helena than in either 1882 or 1883?—A. Yes, sir; but the district was only leveed on the upper half of its front, and the return flow was not done away with, but was increased in intensity.

Examined by Mr. CATCHINGS:

Q. Is it not a fact, Mr. Pharr, that in 1882 and 1883 the whole Yazoo Basin was flooded? In 1882 the upper levee district was not leveed at all, was it? The upper Yazoo district was not organized at that time, was it?—A. I believe it was open.

Q. And the levees all broke in 1882, and the whole Yazoo Basin was under water both years, was it not?—A. Yes, sir.

Q. So that the overflow of the water there might have lowered the gauge at Helena, might it not?—A. Yes, sir; but would have raised the Vicksburg gauge very much when it returned to the Mississippi through the Yazoo River.

Q. And in your judgment didn't it probably have that effect in 1882 and 1883?—A. That is to say, if the water had escaped into the Yazoo Basin it would have lowered?

Q. Would it not have had the effect of lowering the high-water mark at Helena?—A. Yes, sir; it would, as it did when the Flour Lake crevasse occurred; but if the St. Francis Basin had been closed entirely the water would not have been so high at Flour Lake.

Examined by Mr. VEST:

Q. What did I understand you to say is the height of the levees in these two districts?—A. About 9 feet.

Q. About the same in the Missouri as in the Arkansas district?—A. Yes, about the same. They average about 9 feet all along the district.

Q. If I understand you correctly, you think they ought to be built 2 feet higher?—A. I will not say 2 feet higher; I will say 2 feet above the last high water.

Q. What height would that make it?—A. That would add, I suppose, about 2 feet for the whole length. The water of 1897 was very close to the top of our district for the whole length.

Q. That would make the height 11 feet?—A. Yes, sir.

Q. What do you think ought to be the width of those levees at the base?—A. A 3 to 1 slope I think is sufficient. If you have an 11-foot levee, you have a base of 74 feet; that would be a 3 to 1 slope on each side and 8 feet for the crown.

Q. Do you know anything about the crevasse just below Caruthersville?—A. Yes, sir; I have seen it since it broke. I was not there at the time it broke though.

Q. What was the width of that crevasse?—A. It was about 3,100 feet across.

Q. That is all repaired now and in good condition?—A. Yes, sir. It was completed a few days ago.

Q. Was there any other crevasse in the Missouri district?—A. Yes, sir. There was one just above Tyler and one just below Tyler. Tyler is 2 or 3 miles north of the Arkansas and Missouri State line.

Q. What was the width of those two crevasses?—A. They were smaller than the Caruthersville break; they were about 1,500 or 1,600 feet wide each. They were of about the same width.

Q. Have they been repaired?—A. Yes, sir; that is my understanding. I don't know whether the contract is entirely completed or not, but I think it is. All the breaks in Missouri have been closed to a grade only up to the 1897 high water.

Examined by Mr. BERRY:

Q. If both of those St. Francis districts in Missouri and Arkansas were completely closed, can you state how many acres of land which is now subject to overflow would be protected from overflow?—A. I think about 3,000,000 acres.

Q. About 3,000,000 acres of land now subject to overflow in high water would be protected if the levee was high enough to keep the water from going over?—A. Yes, sir.

Q. And you are of the opinion, if I understand you correctly, that the closing of that St. Francis Basin would not increase the height of the water below the St. Francis River?—A. Yes, sir; that is it. I believe if the basin was leveed that 52 feet of water at Cairo will pass Helena at not over 49 feet.

Q. Then instead of this open basin being a protection to the lower country you would regard that the lower country would be safer from overflow with it closed than with it open?—A. Yes, sir.

Examined by Mr. NELSON:

Q. How do you account for your answer to Senator Berry? You said that if the entire basin were closed it would be only 49 feet at Helena. Now, in the flood of 1897, when a good deal of the basin was open and utilized for the water, it was 51.5 and at Cairo in 1897 it was 51.6. Now, your statement to Senator Berry was, that if the basin were entirely closed the water would be only 49 feet at Helena?—A. Forty-nine feet at Helena.

Q. With a 52 gauge at Cairo?—A. Yes, sir; with the St. Francis Basin entirely closed.

Q. In the flood of 1897 it was 51.6 at Cairo, and a large share of the basin was open; crevasses occurred, so that the whole basin was practically filled up, and yet it was 51.5 at Helena. How do you account for that?—A. I account for it partly by the quickened return flow at the mouth of the St. Francis River and partly by the great precipitation we had on top of the crest of the flood.

Q. You mean the rainfall in the basin?—A. Yes, sir; between Cairo and Helena. That was probably a foot. And then the return flow at the mouth of the St. Francis carried the Helena gauge higher than it should go. We would have no return flow if the basins were entirely leveed.

Q. Would not the tendency be, if you contracted the channel of the Mississippi River from commerce at the head of the Crowley Ridge, if you confined the water within the levees the whole distance down, would not the tendency be to raise the surface of the flood?—A. At all intermediate points from the head of the basins to above their point of return flow, yes, sir.

Q. I mean the whole distance, clear down.—A. Yes, sir.

Q. And would it not send it down in greater quantities at once?—A. Yes, sir; at intermediate points, but not at place of return flow.

Q. Then, if a part of the flood went into this basin and dragged along for eight or twelve days, instead of going down in four days, you do not believe that would have any effect upon it?—A. This is my position, Senator: That leveeing the St. Francis Basin, or any basin that overflows into its bottoms, will raise the water at intermediate points along its front, but it will not raise the high-water mark at Helena, but will lower it, because the return flow (that is, the water that has gone over into the basin and into the St. Francis River, and goes down there to the mouth of the St. Francis, just above Helena) comes into the Mississippi, which already has a full river, and it is like two rivers coming together. That is what we call the return flow.

Q. Well, that could only be in case the flood lasted for some time. It could not occur in a short flood?—A. It has to be a considerable flood. The higher and longer the flood the greater the return flow. The basin has to fill up to a great extent. Of course, the more water that gets over into the basin the more return flow we have.

Q. That could not apply in a case where the high stage continued only from eight to ten days very well?—A. No, sir.

Q. Your theory could only be correct in case the river remained at a high stage for a longer period?—A. If this river was a little freshet, and this basin was at the base of a mountain where the water came gushing down very swiftly, then it would be good to leave this basin open as a reservoir, to let the water run off; to fill this basin and let the water run off. But where we have floods of such long duration that this basin is filled, and the river keeps coming down, just about the time that the crest of the high-water wave has reached Helena the return flow of the water that has gone over the bank into the basin comes down through the St. Francis River and it heaps that water into the main river and carries it from 2 to 3 feet higher than it should go. If the water that has gone over into that basin, and has been accumulating there from ten to fifteen days, was allowed to extend itself over a longer period of time and was carried off as it came down, and didn't go into the basin, it would be in the Gulf of Mexico and there would be no return flow from the St. Francis River.

Q. No, but if the whole basin was open the water in the St. Francis Basin would not be flowing down at the same rate of speed and join the crest of the wave in the river at Helena at the same time. The flood

would get down (according to your own statement) in four days, and it would take the other water from eight to twelve days.—A. Yes, sir; but remember that the water has been flowing over into that basin for fifteen or twenty days. The danger line, say, is 40 feet at Cairo and 33 feet at Memphis. Well, the water goes up just above the danger line, rising very slowly. After it gets to that stage there is so much territory and it is running over into that district for forty or fifty days before it reaches its highest stage, and the return flow has begun at the mouth of the St. Francis long before the crest of the flood arrives.

Q. Now, let me ask you in this connection (excuse me for interrupting you): The water pours in mainly at New Madrid, at the head of the levee, does it not? That is where the water pours over?—A. No, sir. Nine-tenths of the water——

Q. I mean out of the river there, where they begun the levee in Missouri.—A. That is where the overflow did begin; yes, sir.

Q. Now, when it pours over liberally, the water sets back there clear up to Commerce, does it not? It not only goes down, but it goes up, after it pours in liberally, does it not?—A. It backs up; yes, sir.

Q. Backs up clear to Commerce?—A. No, sir. There is a very high ridge, above overflow, running from New Madrid in a northwesterly direction clear across the basin.

Q. You notice that chart there [pointing]?—A. Yes, sir. But the water there [on the chart] does not pass around below New Madrid and go back up.

Q. Where does it go to?—A. It goes over from Commerce down—goes right over the bank of the Mississippi River. It does not have to go to New Madrid and then back up.

Q. Well, but does not the water back up from New Madrid?—A. To a certain extent; yes, sir; 10 or 15 miles. But, then, from Commerce down to New Madrid they are in the same fix that we are from New Madrid down; they have got an open front, and the water does not have to go to Madrid to go over; it goes over the banks of the Mississippi and into the bottoms as soon as it gets to Commerce. Of course it will back up above the point of escape in all basins if the flood is of sufficient duration.

Q. Well, it is a fact that, comparing the gauges at Cairo and at Helena, the disproportion was never so great as during the flood of 1897; isn't that true?—A. Yes, sir; that is true.

Examined by Mr. BERRY:

Q. Mr. Pharr, all that you have said with reference to the St. Francis Basin would apply with equal force, would it not, to the Yazoo Basin?—A. Yes, sir; and has so applied.

Q. There is no difference in the two basins in that respect?—A. Not a bit. They have the same hydrographic features in all respects.

Q. And all the arguments that can be made against the closing of the St. Francis Basin would apply with equal force (if there could be any such arguments) to the Yazoo Basin, would they not?—A. Yes, sir; they are the same thing exactly. And leveeing the Yazoo Basin did not raise the water any at Vicksburg, and we claim that leveeing the St. Francis Basin will have the same effect as leveeing the Yazoo Basin.

Examined by Mr. GALLINGER:

Q. Mr. Pharr, can you tell the committee how much farming land along these levee districts has enhanced in value because of the levees that have been built?—A. I have been told that the land in Missouri, in the southeastern corner, if they can hold the levees, has been enhanced

from 25 to 300 per cent. I suppose the same statement would apply to Arkansas.

Q. Now, Mr. Pharr, this committee represents the Government of the United States and you represent a State or a section of a State?—A. A levee district; yes, sir.

Q. Now, in regard to these improvements, I notice by your statement you say that since the organization of the St. Francis levee districts of Arkansas and Missouri, in 1893, to May 6, 1897, the districts have paid for levees already constructed $367,342.14, while the Government has paid $234,036.68. In other words, the levee districts have expended about 50 per cent more than the Government has expended. Now, you say at the close of your statement that when the work under construction to the mouth of the St. Francis River is completed it will cost $1,012,000, and to increase the heights of the levee from the Missouri-Arkansas State line to Pecan Point will cost $265,000, or a total of $1,277,000.—A. Yes, sir.

Q. You furthermore say that to raise the levee of the St. Francis levee district of Missouri 2 feet above the 1897 high-water mark it will cost $160,000?—A. Yes, sir.

Q. And then you suggest that of the first-named sum ($1,277,000) the district is able to raise $277,000 and the Government should contribute $1,000,000?—A. I say we ask the Government to do it in order to give us relief at once. During the last overflow there was more property destroyed in our basin than would build a levee from one end to the other. The value of the property destroyed in our basin would build a levee from one end to the other, twice.

Q. Then (to finish my question) you suggest, Mr. Pharr, that of the first-named sum ($1,277,000) the district, in your opinion, is able to raise $277,000, and that if the work is completed the Government should contribute $1,000,000; while of the second item ($160,000) the district can raise $60,000, and to complete the work the Government should contribute the balance, $100,000; that makes a total of $337,000 for the district, and $1,100,000 to be paid by the Government, or a contribution of over three times as much by the Government as by the districts. Now, what I want to get at, with a view to reaching a practical conclusion on that point is, as to whether or not it is the feeling of the people along those flooded districts that it is the duty of the Government to contribute for the completion of these works, for the building of new levees and the improvement of existing levees, three times as much as the property holders, who are so largely benefited (according to your own statement), will or can raise for that purpose?—A. Well, a great many of the people desire the Government to take complete control of the whole river and all of the levees, and build it all. Whether they think the Government should do it or that they are entitled to it from the Government, I can not say. I can not say what their opinion is, because I have not heard them express it. But the majority of the people want the Government to take charge of the whole thing, from one end to the other.

Q. Of course we can understand that, Mr. Pharr. That would be true of people anywhere. They would be glad, of course, to have the Government expend all the money for internal improvements. But now let me ask you one further question just there. Have the contributions already made by these people in the way of taxation or in whatever form it may have come for the building of these levees been a real burden to them? I think you said in your statement that the revenues to some extent already had been anticipated.—A. Yes, sir. It has been a

burden to them, being subject to the overflow while they have been overflowed. But it is no burden at all if they are protected. Where they pay four cents now of levee tax, they could easily pay two bits an acre if they were protected.

Q. The general feeling among your people is, is it not, that this should be a joint operation; that the people should make some contribution and the Government likewise should make a contribution? In other words, your people, I take it, are willing to have it proceed upon that basis?—A. Yes, sir. They are willing to do all they can to get a levee.

Q. And the matter of a division as to how much the people ought to pay and how much the Government ought to pay depends upon circumstances or the ability of the people to contribute?—A. Or the ability of the people to pay; yes, sir.

Examined by Mr. VEST:

Q. Do not intelligent men who have considered this question down in this country agree that in order to deepen the channel and in order to improve navigation you must confine the water to the channel of the river, and unless you have these levees that navigation suffers?—A. I understand that is the opinion of the majority of the engineers; yes, sir.

Q. But that is an accepted opinion now; that is what these jetties are built for?—A. Yes, sir; that the flood as well as low water must be controlled.

Q. Is not that the reason the United States expends any money upon levees?—A. Yes, sir; that has been their main object.

Q. Not to save private property, but to improve the navigation of the river?—A. Yes, sir.

Q. Now, if the Government undertakes to improve the navigation of the river it ought to protect the instrumentalities that are necessary for that purpose, and the people are willing to do all they can?—A. Yes, sir.

Q. But they think that this thing ought to be done somehow?—A. They want it done, and they are willing to do all they can to have it done.

Mr. BERRY. They want the incidental benefits that would come from the necessary work the Government should do for commerce?

A. Yes, sir; that is what they want, and they want it done right now, before they have to move out.

Q. Don't you believe, as an engineer, that unless the Government of the United States and its means prevent these overflows as they have occurred in the past, and continually recur, the people along this river will have to abandon their plantations?—A. Yes, sir; I do.

Q. And I will ask you if it is not so that various things in late years have contributed enormously to increase the volume of the waters of the Mississippi. For instance, these 10 counties in southeastern Missouri that are being principally drained of their enormous swamps and lakes into the Mississippi, and the destruction of timber upon the upper river, and now this river that is turned into the Mississippi River from Chicago—all those things have increased the difficulties that you have to meet?—A. Yes, sir; the flood arrives faster than it used to.

Q. Why is it, when these overflows occur, this very high water, that in some localities there are threats and even attempts to cut the levees, so as to protect one locality against another: and do they want to cut them above or below the lands that are threatened?—A. They generally cut them below.

Q. Cut them below so as to relieve the upper floods?—A. Yes, sir; there is some talk of that, and levees are always guarded against that during high water.

Mr. CATCHINGS. Don't they cut them above to relieve the land below? Haven't you got that reversed?

A. Yes; generally above and opposite. But I was speaking of cutting them on the same side of the river. You know there is no levee on the other side of the river so far as we have built down.

Mr. CATCHINGS. I understand you now. You were speaking of the same side of the river?

A. Yes, sir. I was speaking of our levee districts.

Examined by Mr. GALLINGER:

Q. What can you say as to the stability and endurance of a modern levee? I have heard it said that perhaps the average life of a levee is about twenty years.—A. Yes, sir. That is the opinion of a great many engineers here on the river.

Q. A levee may, I suppose, be undermined or something happen to it to make a crevasse or to destroy it even within a year after it is built?—A. Certainly. Or it may be in a location where the waves wash, the wind hitting the waves washes it very badly, and it will have to be repaired after every overflow.

Q. So when we talk about the permanent improvement of this great waterway there is no such thing as a permanent improvement?—A. No, sir; there is no such thing as a permanent improvement where you will have to expend no more money. You will have to keep up the works always.

Examined by Mr. VEST:

Q. But if you keep the water from going over a levee it will stand indefinitely, will it not?—A. No, sir.

Q. Well, I understand that when it has once gone over a levee it practically ruins it, but that if you can keep the levee above the water level you can always repair the base of it, unless it amounts to a crevasse, for instance?—A. Yes, that is true. If the water runs over a levee, it will break it, there is no doubt about that; but the wave wash is another thing that will damage it.

Examined by Mr. BERRY:

Q. If they are once built so as to hold the water, the levees could be kept in condition to hold it with comparatively small expense?—A. Yes, sir; the first cost is the great cost.

Q. You would not have to go to the expense of rebuilding the whole work every twenty years, but it could be kept repaired for less than that cost, could it not?—A. Well, estimates are made that the life of a levee is twenty years, and in twenty years a levee has to be rebuilt.

Q. Well, in point of fact, aren't there some levees in Louisiana and Mississippi that have stood for forty years?—A. Yes, sir, and some for one hundred years. And then there are some that have not stood for one year.

Q. But when you have once built permanently and well you do not mean to say that you would have to go to the expense every twenty years of expending the whole amount again, do you?—A. Oh, no; the life of a levee could be extended a long time, even for a hundred years.

Mr. CATCHINGS. Do you mean it could not be kept for over twenty years, or that by keeping it in repair you would have to expend as much as it would originally cost to build it in twenty years?

A. No, sir; I do not mean that. If a levee is built permanently, that is, where there would be no danger of it caving in the river or falling, disappearing totally, I do not mean to say it would cost as much to keep it in repair twenty years as it would to build it.

Mr. CATCHINGS. Well, do you mean that the levee would give way in twenty years?—A. No, sir. When they say the life of a levee is twenty years, they mean that it generally caves into the river, is traveled down, is wave-washed——

Mr. BERRY. Or crawfished?

The WITNESS. Yes, crawfished, and damaged in other ways, so that the repairs, rebuilding, and maintenance, for a period of twenty years, from past experience has amounted to about first cost.

Mr. CATCHINGS. You do not mean to say that the levee itself can not survive over twenty years?

The WITNESS. No, sir; not at all. And since we have had better organization the life of a levee has been increased very greatly, and will continue to increase as the river becomes more thoroughly under control and the banks of the river are made stationary.

JOHN B. DRIVER, sworn, testified as follows:

Examined by Mr. NELSON:

Q. What position do you occupy, Colonel, with reference to levee improvement?—A. I am now president of the St. Francis Levee Board in Arkansas.

Q. Is that a board under the Federal Government or under the State organization?—A. It was created by an act of the legislature of Arkansas. It is a State organization.

Q. The same board of which Mr. Pharr is the engineer?—A. Yes, sir.

Q. How long have you held that position?—A. Since May last. I have been a member of the board since its organization in 1893.

Mr. BERRY. Colonel, how long have you resided on the Mississippi River and been familiar with it in the levee district?

A. Thirty-four years.

Q. You have heard the statements of Engineer Pharr. Do you concur in his views?—A. I concur in most of his views. We differ a little on some matters.

Q. You are familiar, too, with that portion of the so-called St. Francis Basin in Missouri, are you not?—A. Yes, sir; perfectly so.

Q. Waiving the little portions on the east side of the river, is not that basin practically bounded by the Mississippi River from Commerce down on the east, and on the west by what is known as the Crowley Ridge?—A. That is a fact. I will state right here, so as to make the matter plain, that at the organization of our district the legislature of Missouri was in session, and they got a copy of our bill pending before our legislature and had passed a bill exactly like ours, and it was intended at that time—I was a very active man in getting up this matter, was in fact a member of the old board when it was a State institution, and when we drafted this bill and introduced it into the legislature of Arkansas the Missouri people wanted the same character of a law, and they came down and got a copy of our law and introduced it in their legislature, and it was the intention, if such a thing could be done, that both boards should act as one board in operation, but after examining the laws of the two States we found we would have to act separately. They organized a separate board and we organized a separate board, but our chief engineer (the father of this young man, Mr. Pharr, who has just testified) was formerly chief engineer of both boards and held that position until he died.

Q. Of both State boards?—A. Yes, sir.

Q. Now, if I may use the expression, the west high-water bank of the so-called St. Francis Basin was really Crowleys Ridge?—A. Yes, sir; that is right.

Q. And the total area included in that basin is somewhere about 6,000 square miles or a little over, isn't it?—A. Yes, sir. Something over 3,000,000 acres of land.

Q. It would be nearly 4,000,000 acres, would it not?—A. Yes, sir; counting all of it in Arkansas and Missouri together, about 4,000,000 acres.

Q. Some estimate it at even as high as 6,500 square miles.—A. Yes, sir.

Q. So it would be easily 4,000,000 acres?—A. Yes, sir; that includes from Commerce down.

Q. From Commerce to Helena?—A. Yes, sir. When I said 3,000,000 acres, I had in mind that the Commerce section of country gets its water from the Mississippi above Cairo, and when we have a flood in the Ohio River it does not affect the Commerce people at all. Some people connect the two districts and their interests together, but there is quite a distinction.

Q. Now, what was the character of most of the land in this basin below New Madrid, and what was its quality, aside from those dry hummocks, before you commenced to build these levees. Was it not swampy and boggy?—A. Yes, sir.

Q. And unfit for use?—A. Yes, sir.

Q. It was not occupied by settlers, was it?—A. Very few settlers, and they were on the ridges.

Q. It was bogs and swamps?—A. Yes, sir.

Q. And the land was of very little value?—A. Practically of no value.

Q. Who was it owned by mostly before this levee construction was begun?—A. Most of the lands were owned by private individuals, but large plats belong to counties. Now, Missouri has a different system from ours; the lands belong to their counties, and of forfeited lands in Pemiscot County alone, adjoining ours, the southeastern county of Missouri, owned forty-odd thousand acres of land, and it is a very small county.

Q. Of land forfeited for the nonpayment of taxes?—A. Yes, sir. The land was absolutely worthless. The State donated to the levee board of my district the lands belonging within the district.

Q. Yes; but what I want to get at, Colonel, is this: That before this construction of levees was entered into, there was really no farming done there, and the land, except a few of those dry ridges, was unoccupied.—A. Yes, sir.

Q. The rest was a worthless swamp?—A. Yes, sir.

Q. No settlements, and no cultivation?—A. Yes, sir; it would have been impossible to cultivate it.

Q. And only a few of those ridges were occupied?—A. Yes, sir; just a very few; it was but sparsely settled.

Q. Now, taking the stage of water as it was at Cairo in 1883 (52.2), or in 1882 (51.8), or taking it in 1897, supposing there had been no levees at all on the entire length of the St. Francis Basin from Commerce down to Helena, and the water had had free play in the basin, what would have been the average depth of the water, at that high stage, in the basin outside of the river?—A. Well, at one of those extreme overflows the water goes all the way from just over the land to 20 feet in depth.

Q. I do not mean the hummocks, but the ordinary low places. Would

it not have been from 10 to 15 feet deep?—A. Yes; and very often 20 feet. It runs back into the St. Francis River. The country gets lower gradually as it goes back into the St. Francis River.

Q. Then, with all that basin unleveed, with a 52-foot stage of water at Cairo, you would have had then an immense lake in that basin of over 6,000 square miles?—A. Yes, sir.

Q. With a depth of how much?—A. With an average depth of 10 feet.

Q. With a depth of 10 feet?—A. I think so; on the average.

Q. More in places?—A. Yes, sir; and less in some.

Q. Now, shutting off that basin and that lake by levees and confining the water in a narrow channel had some bearing on the flood stages in the river below Helena, did it not?—A. I think it would. I think if we had the river confined—I will explain to the committee this: If you confine the river in a channel, by a system of lévees, you increase the current—it flows much faster. When these lateral currents are cut off or not allowed to flow over the banks, they deaden the current and form these bars, and practically fill up the bed of the river wherever you find these laterals or outflows.

Q. Now, Colonel, is it not the opinion of engineers, and is it not your opinion, that during high stages of water the river does not scour its bed as it does at lower stages of water?—A. Not so much, I don't think; no, sir.

Q. Is it not the fact that as you get the stage of the river higher, the tendency is for the silt to fill up the river, and that the real scouring, the lowering of the bed, occurs more in low stages of water than in high?—A. Not necessarily so.

Q. No; but is not that in general the case?—A. That has been the opinion of a great many engineers.

Q. What is your opinion?—A. My opinion is that if the water can be confined in the bed of the river by any system, levees, dikes, or anything else, that it will scour at any stage.

Q. And that it will not fill at high water any more than at low water?—A. I do not think it will. I have a reason for saying these things. I have lived, as I say, thirty-four years on the banks of this river.

Q. Now, when the floods of 1882 and 1883 occurred, there were no levees built on the St. Francis Basin, as I understand it?—A. Oh, yes; there were.

Q. Well, no material levees?—A. No.

Q. Not such as would pen up water?—A. No; not very much.

Q. There were small old patches in Arkansas, but no long levees that would pen up the water?—A. No; very little.

Q. How do you account for the fact that during those floods, when the water was higher at Cairo than it was in 1897, the stages at Memphis and Helena, and at lower points, were lower than during the flood of 1897, when you had so much of the basin inclosed with levees?—A. Well, that requires a lengthy statement. There was a combination of circumstances that brought about the high water from Cairo south. From just below my town, Osceola, the St. Francis Basin was practically open; but during the time the crest of this wave was passing from Cairo south, the Government gauge at my place showed that we had 12 inches of rain——

Q. Where were you?—A. At Osceola. Twelve inches of rain in forty-eight hours, as the crest of the wave passed from Cairo south past Memphis.

Q. You explain it, then, by the excessive rains that you had in the St. Francis Basin at that time?—A. Yes, sir. That is at least 18 inches of water that we can account for.

Q. That made the great difference?—A. That was partly the cause. Another cause was, that the water had been confined from New Madrid south to Osceola, about 80 miles, and the current was flowing so much faster than usual that it forced itself past and raised the flood line at Memphis. And when it tore through at Helena it had the same effect, because it went through there much quicker than it had been in the habit of doing before. Heretofore it has taken the water, as Mr. Pharr and as all engineers will tell you, from eight to sixteen and eighteen days to pass down the St. Francis Basin and get down to Helena, but in 1897 it passed through in half the time, and it all came out, you understand—there is a thing very few people think about—this water, as I say, was forced down the river as far as our place, in the channel altogether, which increased the current, and when the water commenced going over the banks it checked the flow and piled up faster.

Q. You mean there was no break—no way for the water to get into the basin until it reached your point?—A. Yes. The breaks occurred just as the water came to a stand—the breaks above our place. Now (this, of course, is simply my opinion, but it is fortified by the facts that we know existed at the time), just about the time the water came to a stand—this water had all been kept inside of the river—the breaks occurred just below my place, when the water was 49 feet at Cairo. When the first break occurred just below Osceola, of course this water had been forced out and it piled up in Memphis much faster than it did in 1882 and 1883; that is one thing that increased it.

Q. Your own experience, then, indicates that because of the penning up of the water as it had been penned up above, it came to you in such a preponderating force that it broke the old weak levees below you?—A. Yes, sir.

Q. And that was owing to the fact that the confinement of the river above by the levees during this last flood caused the water to come in a heavier volume onto your levees below Osceola than it ever did before?—Yes, sir. There is no doubt about it.

Q. And that was owing to the penning up?—A. Yes, sir.

Q. Now, could not what occurred with you have occurred below Helena in like manner?—A. Now, understand me; I say it will increase the flood line at Memphis, but I do not believe it will ever increase the flood line at Helena, because, if you will notice the gauge readings, the Helena and the Cairo gauge show nearly the same thing.

Q. The gauge readings during the last flood, at Memphis and at Helena, indicate that the rise was much greater in proportion at Helena than at Memphis. The gauge reading in 1883, at Cairo, was 5.6 and at Memphis 37.1, and at Helena the gauge reading was 51.5. How do you account for that?—A. I account for that in this way: Half the distance that this water had to go down through the St. Francis Basin, in 1897, was absolutely cut off from Helena, and it only took half the time for the water that passed above Memphis to pass Helena than it would if it had gone out at Point Pleasant, Mo., because it is only about half the distance. That increased the height of the water there, because the rivers came together above Helena, you understand. Heretofore it has taken it a long time to pass out through that basin, because it is full of undergrowth, logs, timber, and all sorts of obstructions. But from Osceola down the country is more open than it is above, a great deal more, because there is more cleared land; and it passes out at

Helena much quicker now than it used to, and was the cause, I think, of the Helena gauge going so much higher than it usually does.

Q. Because it passed more rapidly out of the basin?—A. Yes, sir; the route having been shortened at least half the distance for the water that went in the basin, it piled up there at about the same time, because the distance is much shorter through the St. Francis Basin than through the main river.

Q. Do you mean to say that the progress of the water, that in the basin and that in the river, was simultaneous then?—A. Almost so, having an open country to pass through.

Q. The water in the basin from Memphis down flowed as fast as in the river?—A. It did not flow as fast, but, you understand, the distance is much shorter, and there were not the obstructions below, when the water passed, that there had been before, and the water passed out much quicker and raised the water gauge at Helena outrageously high; much higher than it ought to have been and much higher than it ever will be seen again, I think, after this basin is closed.

Q. Higher than it was known before?—A. Yes, sir; and higher than will ever be known again, I hope. Because, as I say, in addition to that we had 12 inches of rain. We have a gauge at our place (one of those receptacles the Government furnishes), and in forty-eight hours we had 12 inches of rain, and the water from the rains was pouring down on both sides of the basin, being hilly on both sides, and concentrating at the mouth; and I am satisfied it raised the water at the mouth of the St. Francis 18 inches above what it would have been if it had not been for the rain.

Q. That you had during the flow of that water?—A. Yes, sir; as the crest of the wave was passing south.

Q. Now, when the river is at high stages and the water overflows below New Madrid and breaks into the basin, what is the time of the flow of the water in the basin as compared with that in the river?—A. It takes about three-fourths or four-fifths longer to go down through the basin than in the river.

Q. Well, how many days, say, from New Madrid, or where the head of the levee is there, down to Helena?—A. It generally takes it two weeks.

Q. Two weeks in the river?—A. No; in the basin.

Q. And how long in the river?—A. From three and one-half to four days.

Q. In one case it would be four days and in the other it would be fourteen days?—A. Yes, sir; and sometimes longer.

Q. A difference of ten days?—A. Yes, sir; fully that much.

Q. Now, then, if the crest of the flood did not last more than eight or nine days, manifestly under those conditions it would be a relief to the river to have a part of its waters in the basin, would it not?—A. Yes, sir, it would be to the river below Helena. I believe it would—a short time like that.

Q. Now, we are directed by the resolution to inquire whether we can relieve against floods by means of reservoirs. What is your idea of constructing a great reservoir with Crowley Ridge as the western boundary from Commerce down to Helena, and turning all the basin there into one great reservoir. What is your opinion of that, and what would be the effect of such a reservoir upon the river in diminishing floods below?—A. I suppose if that could be done it would help some: there is no doubt about that; but it would destroy the greatest and richest body of land in America.

Q. Are you able to tell, Colonel, about what is the stage of the river

:o when the river is up to its natural banks?—A. It is about 42
Forty feet is called the danger line. But you understand they
›y that that it flows out into the little bayous and tributaries.
t is, say, 40 feet?—A. Forty-two feet, say. At 42 feet it never
anybody much.
Iow, taking a 52-foot stage—that was substantially the 1883 stage
:o?—A. Yes, sir.
'hat would make an overflow of 10 feet?—A. Yes, sir.
And if the flood did not last but eight or ten days, could not that
s water (10 feet above the natural bank) be retained in that St.
s Basin of over 6,000 square miles at a depth of, say, 12 feet?—
o not think it could.
)r a large share of it?—A. Well, a good deal of it could be put
'e.
And could it not be substantially retained for, say, twelve to four-
ays?—A. No, sir; it could not.
)r ten days?—A. It is possible you could retain it for a week, but
e this river now has got so that it does not overflow like it used
ormerly, when the river rose we usually had a month to get
in shape to meet it, but now it comes right down on us all of a
ı. Now, all this northern country up the Ohio River and up the
sippi River, up through Illinois, Tennessee, Missouri, and all that
y, is being cleared and ditched, and all the bayous and lakes are
d out into the river, and when the water comes now it comes like
pouring from a roof, and comes down on us before we know it,
, and it would be impossible to construct a reservoir that would
any relief.
BERRY. The condition of the country is such that it would be
impossible to hold that water in a reservoir, would it not?
do not see how you could do it.
BERRY. Would not the cost of it, after you had paid for all the
verflowed and destroyed, as well as the expense of constructing
ervoir, cost more than to levee the district?
t would cost more to do that than to make a levee from Com-
Mo., to the Gulf with rock. You might make a cement wall
r.
GALLINGER. Is there any known way by which you could divert
into such a reservoir and hold it?
BERRY. An immense quantity of water could not be held in that
untry.
)h, no; I don't think it could. You might be able to hold it for
, possibly.
Iou would not be able to hold it as you could in a mill pond, but
ould it be to leave it as a free basin?—A. No, sir; you could not
. You would have to build an immense wall below, because the
immense. After you get back into the St. Francis Basin—if you
stood the geography of the country you could well understand
could not be held.
Well, it slopes from the Mississippi back?—A. Yes, until you get
St. Francis, and you see the distance is so much greater by the
iver than it is through that basin that you just could not hold it:
all.
CATCHINGS. A fall of about 120 feet?
Yes, sir.
n your opinion, then, it would not be possible to make a reservoir
—A. I do not think it could be done at all.
f it is not possible to make a reservoir there, can you conceive of

any other point down the river where a reservoir could be built?—do not think you could build a reservoir down in this country. might if you had mountains on either side and then banked up to the water, but in this low country you can not do it.

Q. If you could not make a reservoir out of the St. Francis Basin could not anywhere else below?—A. I do not think you could.

Q. Now, before this levee building took place, is it not a fact about 90 per cent of all the lands in the basin were practically w less?—A. Yes, sir; fully 90 per cent.

Q. Over 90 per cent?—A. Yes, sir; practically.

Q. Who are those lands owned by mostly; by small holders own a little bit, or by large syndicates that own great tracts?—A. when we passed the levee law creating this district, large land s cates owned a good deal, but they have sold off, and people are m into the district—thousands of them—since we began to buil levees, and they are now purchasing this land.

Q. But before the building of levees the lands were owned la by large land syndicates?—A. Yes, sir.

Q. And except where the levee system has operated to advanta they could sell, they are still owned by these syndicates?

Mr. BERRY. Not syndicates as much as it is individuals, is it?

The WITNESS. Oh, no. The majority of the lands, you unders are held by individuals, but there are four or five syndicates that a great deal of the land in the basin, the Memphis Land and Ti Company; the Chatfield Land Company, of Cincinnati; the C Land Company, of St. Louis, and three or four other corporations several thousand acres of the land in the district.

Examined by Mr. BERRY:

Q. Colonel, do you think, with levees properly constructed from to the Gulf, and to the height you usually regard as being safe (s or 12 feet on an average, or 15, whatever it may be), that the river can be confined within those levees?—A. There is no doubt i mind about it at all.

Q. You feel confident that it can be done, do you?—A. Yes, sir. last overflow demonstrated the fact that we can hold the levees ag any overflow.

Q. Is it not a fact that many of these crevasses that occurred i levees were in levees built back in the fifties—before the war Every one that occurred in my district were in levees built from to 1856.

Q. And were the old levees?—A. Old levees that were practi of no service at all. They were old, built on logs and brush, and u mined by the moles and rats, and they were in bad shape. Th system of building levees, I will state to the committee, was to le work to contractors and had no one to supervise or control them was not done in the way we build levees to-day. The first break occurred in my county occurred right in the center of my place Mr. Hale, a neighbor of mine, told me, and I know it is a fact, th helped build the very levee that broke, and he said they filled u levee with large logs and that they left a stump in the levee—the s is standing right in the break now. They cut down a sycamore t feet in diameter, cut off the top, and built the levee over it; well all decayed. I was within 60 feet of the break when it occurred, the levee actually dropped right in; the whole top fell right in. I there and witnessed it. It was practically undermined by this Now, when we build levees there is not a stick or a piece of b

llowed to go in as big as your thumb; there is an engineer every little listance, and an assistant stands over the men and sees that nothing hat will decay goes in. And all of our new levees in the St. Francis front stood during the flood and are standing to-day. We had miles and miles of levee in our district that the water ran over for twenty-four hours at a time and it didn't affect the levee a bit; the levee stands there to-day as good as when it was built.

Q. What is the average height of the levees along the St. Francis Basin?—A. Mr. Pharr says about 9 feet. I don't think it runs quite that. I think an 8-foot average would be a full average. And I think 18 inches to 2 feet more will make the levees practically above any water that we may ever see. Now, in my neighborhood, in fact in all my county—I was not president of the levee board during the overflow, but I was on the levees all the time, being a member of the board, and I worked very hard to save the levees; and on the new levees the water just got up to in some places from 6 inches to 3 feet of the top. A good many of our levees were 3 feet out of the water, which is a very remarkable fact. Now, the levees are all built absolutely level; there is a level run over all of them, and they are all supposed to be exactly the same height above the water; but sometimes the water will be higher in one place than in another—for instance where it flows around a point on a curve in the levee below that it will fill up. There is no currrent to carry it away and the water banks up and gets near to the top, while where the current is swift the levees may stand 2 and 3 feet above the water of last year's height.

Q. What is the effect on the land where a crevasse occurs; does it wash the land out sometimes?—A. It nearly ruins a place. I had a place damaged a great deal from a break last year. I lost my houses and everything anywhere near the break. The fences washed down. I lost about 60 acres of potatoes that would have been worth $40 an acre to me.

Q. Well, sometimes does it destroy the land itself?—A. Yes, sir; it washes it out in holes, and builds sand banks, etc. One thing will occur at one break and another at another. Sometimes the break will occur in a sandy place, and it will wash out the white sand over the land and damage it.

Q. And sometimes when it backs up on it it does not hurt it?—A. Yes, sir; does not hurt it at all when it backs up, except right immediately, you know. After it drys off it is all right.

Mr. GALLINGER. You say that in your opinion it is practicable to levee this great river from Cairo down. Could you suggest to the committee what, in your opinion, would be the approximate cost of such an enterprise?

A. Well, sir, we have made up statements. From our practical knowledge of levee building we think our district can be leveed for about $1,200,000, with a levee that will be practically above any water we have ever had.

Q. Do you mean the whole St. Francis levee?—A. Yes, sir.

Q. Clear from Missouri down to Helena?—A. Yes, sir; from Point Pleasant, Mo., to Helena, Ark.

Mr. GALLINGER. I wish you would state, if you can, what would be the approximate cost of the completion of this entire enterprise which you say is practicable.

A. Well, I have stated it from Point Pleasant. I have not the data above Point Pleasant.

Mr. GALLINGER. I mean, to build it from Cairo to the Gulf.

A. I could not answer as to that, because I have not the area above New Madrid.

Mr. BERRY. I think you have not understood his question yet. Senator Gallinger wants to know how much more money it would take to complete the levees from Cairo to the Gulf of Mexico, on each side, than has already been expended.

By Mr. GALLINGER:

Q. That is precisely what I want to know. Suppose we go back to Washington and say (giving you and other learned men as our authority) that we believe it practicable to build a system of levees from Cairo to the Gulf, and should be asked: "Well, how much will it cost?" What is our answer?—A. Well, I didn't understand your question at first. I thought you were asking me as to the section of country I am familiar with. Well, sir, we figure it will take about $18,000,000, in round numbers, to complete the levee system.

Q. That is the amount stated in the last report of the Mississippi River Commission, is it not?—A. Yes, sir; and we have taken that up and discussed it among ourselves, and that is our determination and opinion.

Q. If I understood you correctly, in giving your testimony, you said that in your opinion the water, both at flood tide and at low tide, scoured the bed of the river. Did I understand you correctly?—A. Yes, sir. Now, you understand me, that if the water is confined within its banks by any system, I believe the river will scour at flood tide as well as it will at low water. It might not scour exactly to the same depth across a bar, but the scouring will go on if the water is confined. There is no doubt in my mind about it.

Q. Now, I have read conflicting statements on that point. I think I am correct in saying that some engineers say there is a process of scouring going on, lowering the bed of the river, and others say that the bed of the river is being elevated, and I have seen some remarkable statements as to the elevation of the bed of the river, even going to the extent of saying the bed is even higher than the territory outside of the banks. Now, what is your opinion as to that matter?—A. My opinion is that when a man makes such a statement he has not reflected on what he is talking about. My opinion is that the river will scour out its channel if it is confined. Very often you will find a bad place in the river in a bend, but you will nearly always find that there is a lateral current that is led away from there just above, which forces a deposit below—deadens the current, you understand—which proves to us that that is correct. Now, when the Government commenced work, several years ago, and sent Captain Knight to take charge at Plum Point, Tenn., he conceived the idea of building a levee on both sides of the river. Our people had 35 miles of levee already built on the Arkansas side. He concluded then that he would build from Ashport, Tenn., to Plum Point down, to show the practical results of that levee. Well, when he built the levee there were some people in my neighborhood who had the idea that it was going to run the water right over our levees. In fact, my nearest neighbor, a man by the name of Driver, but not related to me, took the position that we would have to raise our levees, and we went to work and raised our own levees. After that levee was built, taking the same high-water gauge at Cairo, it lowered the gauge at our town 7 inches. This I know of my own knowledge. I have lived there all the time. We were very restless and uneasy about it, because I believed the story of these old people that lived there for a very long time. I believed they were right about it, and I

went to work and raised my levee in front of my place; and when the water had gotten to the same gauge it was two years before, it lacked 6 or 7 inches of being as high at our place as it was before.

Q. Then the bed must have gone down?—A. I will say that the year before that I saw 13 steamboats aground and lying waiting above and below the crossing in front of my town, and after Captain Knight built that levee it scoured out a channel there, and I have never seen a boat aground there since. Now, that is a practical test of the matter, I think.

Mr. NELSON. A levee on both sides?

The WITNESS. Yes, sir.

Q. One office of our inquiry is to determine whether it is feasible to relieve the high water of the Mississippi River by what is known as the outlet system. Have you given any consideration to that subject; and if so, what is your opinion?—A. An outlet system is practically impossible until you get to the mouth of the Red River, and I will tell you why. I have given the matter a great deal of study, and I have maps and diagrams of the whole country along down. Until you get to the mouth of the Red River we have this sort of a system: We will commence, for instance, at the St. Francis River; it heads up in the highlands in Missouri and flows into the Mississippi at Helena. You go down to the White River, and it is the same thing. Then you go to the Arkansas River, and it is the same thing. Now, between those rivers it is hilly—highlands. It would be impracticable, for instance, to make an outlet across Crowley's Ridge. If you did so, you would run the water into White River and then it would go back into the Mississippi below Helena, and if you go to the Arkansas River, you bring the water back into the Mississippi 12 miles below White River; and if you cut across Arkansas and go into the Red River, it would return again.

Mr. NELSON. Into the Tensas?

The WITNESS. Yes, sir; you then come to one place where the outlet system would be practicable. When you come to the mouth of the Red River, I believe if they would go down through the Atchafalaya and the Tensas basin that they could go into the Gulf a nearer route and would possibly relieve the river below, but it is very questionable even then. But an outlet system above the mouth of the Red River is practically impossible; it can not be done.

Examined by Mr. CATCHINGS:

Q. Didn't about 400,000 cubic feet per second go down the Atchafalaya River during the flood of 1897?—A. Yes, sir; they say so.

Q. So you did have a great outlet there?—A. Yes, sir.

Examined by Mr. GALLINGER:

Q. Senator Caffrey has suggested to me that in his opinion sooner or later the Mississippi River will go down that way, anyway.—A. Well, I would not be surprised.

Q. Have you looked that up at all?—A. Not particularly.

Q. Well, are you familiar with Captain Cowden's scheme?—A. Yes, sir.

Q. Do you think that is impracticable.—A. Yes, sir; I do.

Mr. NELSON. That plan is to carry the water into Lake Borgne, isn't it.—A. Yes, sir.

Examined by Mr. VEST:

Q. Colonel, you can not have the jetty and outlet system too?—A. No, sir.

Q. You have to take one or the other?—A. Yes, sir; that is my opinion of the matter. Now, I want to say, for the benefit of the committee, that I took this position at the Davenport convention last October and I wanted to file a paper, but we got in too big a hurry and all the delegates got away from there, that this river can not only be leveed and reclaimed, but that without a very large cost its banks can be protected with the same effect. Now, the Mississippi River Commission takes the position that the willows along the banks will give out, and that they will not be able to build mattresses much longer —only about 10 miles a year. Well, now, at my place (I am not living at Osceola, I am 4 miles above there now at Luxora) the river commenced caving a few years ago and the Government engineers thought they would stop the caving, and they didn't have the willows and they ran out three or four regular dikes; they drove their piling some 6 feet apart and would wire them in and then drop the rock in between, running out away past the caving. Well, sir, they have practically stopped all that caving. They did it at once. Since that it has had no tendency to cave at all. And I believe that this rock dike system, 200 or 300 feet apart wherever you have a caving bend, will stop the caving, and that the current will clean out these bars until the river is cleaned out clear to the gulf.

Mr. NELSON. That is on the principle of wing dams?

The WITNESS. Yes, sir; I believe that the levee system and that rock-dike or dike system settles the matter of navigation and reclamation of the river.

Examined by Mr. CATCHINGS:

Q. Was not one objection the commission made to any further work of revetment as part of a general system the extreme cost of it?—A. Yes, sir.

Q. Not only that they could not get willows enough to make their willow mattresses, but the extreme cost?—A. Yes, sir.

Q. That it would cost the enormous sum of $134,000,000 to revet the banks from Cairo to the mouth of the Red River and that it would cost 10 per cent of that each year for revetments; so when they had done sufficient work to test its enormous cost they said not only that they could not do it for want of willows, but because the cost was so great that the Government could not be expected to enter into that scheme?—A. Now, my idea, General, is that that can be done by the rock-dike system much cheaper than it can by the willow mats and be of a permanent nature, lasting for ages, and would not cost but very little to maintain and keep in repair.

Examined by Mr. NELSON:

Q. Now, the revetment system is not like the wing-dam system, is it? By revetment I understand is meant fortifying the banks by riprapping in bends.—A. Yes, sir.

Q. And that is distinct from the wing-dam business?—A. Yes, sir.

Q. Now their estimate was for the riprapping, that was very expensive?—A. Yes, sir.

Q. But the other system, the wing-dam system, can do a great deal of good and not necessitate a tenth of the expense?—A. That is exactly my position. I came to that conclusion by actually seeing it tested. And you will have a good river, that will scour itself out.

Q. Don't you think it is more judicious, in view of the experience of the last flood, to first fortify and perfect the levee system below Helena before entirely closing up the St. Francis Basin?—A. No, sir.

In other words, do you think it would be safe to close up that n first before fortifying the levees below?—A. Yes, sir. I think closing of that basin will absolutely lower the water. I am honest hat opinion, and can give the opinion of several engineers to bear it. I think so for the very reason that I tell you, when the water s down in the St. Francis Basin it piles up on them below just like breaking of a dam. If you confine the water, it will pass down at ore uniform level and will not pile up on them below.

By Mr. BERRY:

). And there is no more reason for keeping the St. Francis Basin n than for keeping the Yazoo open?—A. Not a bit in the world. d the fact is, that closing the Yazoo Basin did not raise the water at ksburg, and the same conditions exist there as at Helena.

Ir. NELSON. I had always supposed that in building levees, taking country in a state of nature where none had been built, that it ld be the wisest, safest, and most prudent course to commence from ow and work upstream; that it would not be safe to commence stream and work down.

A. No, sir; I think it ought to have commenced above at the start. ink the system was commenced wrong.

). You think, then, that this levee system should have been commenced at Cairo or near there, instead of below New Orleans?—A. Yes, ; I do.

). In the first instance?—A. Yes; I think it would have been better.

). Then, according to your theory, the St. Francis Basin ought to e been closed before the Yazoo Basin was?—A. Yes, sir; I think it ld have been better for the country below.

Ir. BERRY. Colonel, is there anything else you would like to state?

he WITNESS. As we go down the river I would like to have you d at two or three points to show you what we are doing. We have y about 10 per cent of our land in cultivation, and the people are paying all the taxes they are able to pay, and a great many are ing more than they ought to pay.

Examined by Mr. NELSON:

). In that connection, Colonel, don't you think it would be fair that se people who own large tracts of these unimproved lands—I do not an those who have taken lands and commenced to improve them—t don't you think these other people who own a lot of these lands t are now of little or no value, and whose lands would increase in ue by the perfection of the levee system from 25 to 300 per cent, n't you think it would be fair that they should contribute something ard the cost of this levee system above all others?—A. I feel that y, but, you see, under our constitution and laws of our State taxon must be uniform.

). Yes, I know; but would it not be fair, in your opinion, that these n—I do not mean settlers who have their little claims started, but I an those who own these lands and hold them for speculation to ke money out of them—don't you think it would be fair that they y one-half of this expense?—A. I do. I think they ought to do it; t under our laws we can only make them pay what others pay.

). And if the Government of the United States were to contribute e-half, would it be unjust to make them pay the other half?—A. I n't think it would. But here is the trouble, Senator: It would have be raised by taxation, you understand. Now, we anticipate our reves ahead. The revenues in my district are about $60.000 a year, and

that will build from 10 to 12 miles of levee, and in some localities 15 to 18. But as it would take us probably eight or nine years to complete our levee system, if we have it to do ourselves, in the meantime a great many of our people in the lower part of the district are suffering from inundation every year, and those people have all they can stand now to hold their own. Of course, some of our people are now getting the benefit of this levee system, because our board adopted a regular system at the start, commencing the levees at the upper end of the basin and building down, because when we build a mile of levee we protect a great many people back of the levee. There are eight counties in my levee district, and, you see, the upper counties get the benefit of the money that is spent, and the people in the lower counties go on paying money year after year and derive no benefit; and in justice to those people I would be willing to do anything to protect them. I went before the last Arkansas legislature and got a bond act passed, but they incorporated a proviso in the act that unless the Government contributed $750,000 we could not issue the $500,000 in bonds that we had asked the legislature to let us issue, and that knocked out the object of the bill, because the Government was not going to be forced to do anything. We were then asking the Goverment to contribute something to help us, and that is all we could do. That proviso practically killed the bond bill. But I am going before the next legislature and ask them to allow us to issue the bonds. Give us that right, and I can float the bonds for a hundred cents on the dollar. The credit of our district is well established, and you can not buy its paper to-day for 99 cents on the dollar anywhere. We have kept our credit good, and I am going to maintain it as long as I am the executive officer of the district. If I can get bonds issued, say $700,000 or $500,000, I can go on, with the assistance of the commission, and, as I believe, could complete this levee system in the next three or four years. But that is a long time to wait for the man who is in the water and often losing his crops.

Q. Now, if you had an ample supply of money—I mean a reasonable amount, what would be fair—how long would it take you to complete the whole St. Francis Basin levees? If there were ample money, in what time could it be completed?—A. We could have a levee system completed within eighteen months if we had the funds at our command.

Q. All of it?—A. Yes, sir; all of it.

Q. Do you take into consideration the fact that you will have to fortify or build higher the present levees?—A. Well, we have built now, as Mr. Pharr tells you, over 80 miles of levees, and the increased heights of those levees satisfies us now that we have reached the maximum.

Q. Now, if your theory is correct about the building of levees there, it seems to me it would not be necessary to increase your 9-foot levees in height. Your theory is it would not increase the crest of the flood wave to inclose the river by levees. If your theory is correct, there ought not to be any necessity for higher levees.—A. I am glad you called my attention to that. The old rule, the first rule adopted by us to build levees, we found was too low. Now we have raised the height called for by the old rule. We have now raised our gauge 2 feet, and we are building all of our new levees according to the new system, you understand.

Q. On a basis of 2 feet above the flood of 1883?—A. Of 1897. You see we have had a practical test of that for 80 miles, and it shows just what we may depend upon in the future. We have raised our gauge now 2 feet higher than we had it before, which will give us all the

oom we want; that will build our levees higher, I am satisfied, than we vill ever see the water again.

Mr. BERRY. You think if the Government will give you $1,000,000 that within two years you could have the whole system built and be practically free from any ordinary danger?

A. Yes, sir; and then we can take care of the levees after that. Our assessment is $60,000 a year, and it will be increased to $75,000 in a year or two. And the lands that the State gave us by an act of the legislature we are now putting on the market and selling for $1 an acre, and yield considerable revenue.

Q. The State has practically devoted those lands to levee improvements?—A. Yes, sir; gave it to us for levee purposes, and we are now selling it at $1 an acre. I sold several thousand dollars worth of land recently, and we put the money into levees as fast as we can sell the lands.

Witness produced the following paper, marked "Exhibit U," for incorporation into the record:

EXHIBIT U.

POINDEXTER, ARK., *January 20, 1898.*

The CHAIRMAN OF THE COMMITTEE ON COMMERCE,
United States Senate:

In 1850, when the first aid was given by the United States Government for the purpose of reclaiming the basin lands of the Mississippi River, which was in the shape of a grant to the States of the unsold swamp and overflowed lands within their limits, to provide a fund for reclaiming the districts liable to inundation, there was great alarm in Louisiana, as the upper basins were believed to act as reservoirs, and it was imagined that if they were closed by levees the lower country would be unavoidably overflowed whenever the river rose to flood line along its upper basins.

The aid of the Government was invoked, and Congress immediately ordered the necessary investigations and surveys. The work was placed in charge of Captain (afterwards General) Humphreys. There was ten years of surveying, investigation, and construction, an elaborate report of which was published just after the outbreak of our civil war in 1861.

It was fully established by measurement, observation, and construction that the basins above Red River did not serve as reservoirs to diminish the maximum wave which passed through Louisiana in great flood seasons. The basins had already become filled with water, escaping into them from the Mississippi River—rain water, and their own natural feeders flowing in on their sides opposite the main river. The survey fully established the fact that no natural reservoirs existed, and no artificial ones could be constructed that would keep back the spring freshets, which caused the floods; that no diversion of tributaries or making of cut-offs could in the least be made beneficial, but would be in the highest degree injurious; that while outlets were theoretically advantageous, they were impracticable from the lack of suitable sites; and, finally, that levees properly constructed and judiciously placed would afford protection, and the only practical protection to the entire alluvial region.

At the beginning of the year 1861, from the proceeds of the swamp-land act, private enterprise, and corporate organization the levees had been almost completed from the passes to Commerce, Mo. During the civil war, from neglect and inattention they were largely destroyed, but soon after the war closed their reconstruction commenced, and was prosecuted with more or less vigor up to 1879, when the Mississippi River Commission was created by Congress, which gave new energy to levee construction, particularly after the allotment of $1,300,000 to close the crevasses made in the levees by the flood of 1882.

This being the first money ever directly expended by the Government for levee construction on the Mississippi River, the people immediately bestirred themselves to organizing and making preparations to complete the whole levee system. Those inhabiting the basins organized levee districts and obtained from their State legislatures corporate privileges to levy tax on benefited property and do all things necessary to build and maintain levees. Aided by the very liberal spirit of the gentlemen composing the Mississippi River Commission, the work in the Atchafalaya, Tensas, and Yazoo basins made rapid progress and without friction of engineers up to about the year 1893, when the people of the St. Francis Basin began to take very active steps to levee their front. Then the cry of alarm that had not been heard since

the publishing of General Humphrey's report was again raised, and, very strange to say, some of the river engineers joined in the chorus that if the St. Francis Basin was closed it would necessitate the raising of the levees protecting the lower basins.

It is to the closing of the St. Francis Basin and the theoretical assertions of some that it will increase the height of floods along the levees of the lower basins that I wish to particularly call the attention of the gentlemen of the committee; and I here make the assertion that the closing of the St. Francis Basin will not during long rises increase the strain on the lower levees, but will actually have a relieving influence. I make this assertion without the least fear of contradiction, based on the laws of hydromechanics.

Now, for the proof. The lower St. Francis Basin is now leveed from Point Pleasant, Mo., to a point about 60 miles (straight line) above the mouth of the St. Francis River, leaving below the end of the levee, counting something for back water, about 2,300 square miles subject to overflow. When the Mississippi rises to flood line it will take this part of the basin about six or eight days to fill. Now, if the flood line continues above for a longer period than eight days, then the accumulated water in the basin will be flowing out at its lower end, which will cause a secondary rise in the Mississippi below the mouth of the basin; hence there will be additional strain on the lower levees.

If we take a trough capable of emptying 500 gallons of water per minute and construct a reservoir at a point near its upper end that will hold 100,000 gallons and make an overflow into the reservoir sufficient to let in 250 gallons per minute, we lower the water line in the lower end of the trough one-half. Now, if the supply of water remains the same after the reservoir is full, the lower end of the trough will again fill back so as to empty 500 gallons per minute; but if the reservoir was so constructed as to discharge back into the trough at a point above the lower end, and it commenced to discharge after a lapse of four hundred minutes and the supply in the receiving end of the trough remains the same, then the additional discharge of the reservoir will be bound to overflow the lower end of the trough.

It seems that some of the river engineers have forgotten their text-books or are disregarding the laws of hydrodynamics. They are talking much about abnormal floods. There is no such thing as abnornal floods in the sense that they use the term. What they term abnormal are secondary rises, and are as regular in their action as any of the other laws governing hydraulics.

When the river flows over its banks and the water commences to flow to the back part of the basin, every ridge, tree, limb, twig, fence, house, or other obstruction acts as a dam to pile the water up and make its bulk more. And when large basins like the St. Francis fill with water, and the Mississippi River and St. Francis River draw off the water from the edges, the water in the basin forms two arcs, having their origin at the same point, somewhere between the two rivers; both arcs having one and the same versed sine. Sometimes during high floods in the St. Francis Basin in certain localities the diameter of these versed sines amounts to as much as 6 or 8 feet. The formation of these arcs and the slacking of the current at their origin was the cause of the formation of the ridges and high lands in the basin. I suspect that the existence of these arcs during high water has led Captain Townsend, Corps of Engineers, U. S. A., and others, to advance the erroneous theory:

"That after the basins have filled with water, the water in the basins then acts as a levee to restrain more water in the river."

While it is impractical to measure every tree, limb, etc., that acts as dams, or to take the diameter of the versed sines of the many arcs, yet if the data was taken the mathematical calculation of the amount of water flowing through any cross section taken at any point on the river during its normal stage, the approximation can be about as correctly made as the approximation for difference in amount of earthwork for a levee on concave and convex bends on the river. And constructing engineers should make approximate provisions for secondary rises that are sure to follow the above-stated causes.

There is one other factor which I wish to call attention to that very much endangers the levee on the Yazoo side immediately above the mouth of the St. Francis River. The laws of pneumatics and hydraulics act in opposite directions, as when two currents of air meet they form convex bends and relieve themselves on top; but currents of water meeting or approaching at angles can not do this and must relieve themselves by whirls, sucks, and eddies.

When the St. Francis Basin during floods is emptying at the mouth of St. Francis River, owing to the commingling of the waters heavily charged with silt, the resulting eddies cause the river to silt up its channel and cause a very material strain on the levee immediately above the inflow. When the basin is leveed this strain will be almost reduced to zero point. Though with a tributary draining the large area that the Arkansas River does, this will be always a source of danger to the levees on both banks immediately above its mouth.

Some precedents.—The Po River, in proportion to the whole area of its drainage,

the largest amount of basin of any river in the world. For many centuries following the sixth of the Christian era, during the barbarian invasion of Rome, much the protection system of the basin lands of the Po was allowed to fall into decay; it during the latter part of the middle ages, when the work was resumed, the building commenced in the lower basins.

The engineers found great difficulty in making the dikes hold during the long-continued floods in the spring season. There arose a school of engineers who contended that the only safety to the lower dikes consisted in embanking the upper basins. By the close of the fifteenth century this system was put into operation, and since that period the lower dikes have not given any serious engineering difficulties.

In 1879, when the River Theiss broke its embankment and overflowed a large tract of the plains of Hungary, and did great damage to the city of Szegedin, after the subsidence of the floods, and the embankments were rebuilt, the engineers found by calculation that the river was not discharging as much water below the place of the break, at the same gauge reading, as it did previous to the break. On investigation it was found that the river channel for several miles below the outflow of the break had settled up. By building the embankments higher along this vicinity and confining the water in the channel they found that after a few rises in the river the water had dredged out the channel and that the river would discharge its normal amount of water at the previous gauge reading.

The European Commission of the Danube was an effect of the treaty of Paris of March, 1856. Under this treaty the Danube was placed under the protection of international law and declared free to the ships of all nations. When the commission assembled at Glatz for the purpose of putting the deltaic portion of the Danube in the best possible state for navigation, there was much contention as to which pass should be improved, what should be the mode, etc. A part of the contention was against building embankments. When the Sulina mouth was finally improved, under the supervision of Sir Charles Hartley, which consisted of piers and the embankment of the channel up the delta, the effect of this improvement was to increase the depth of the channel from 9 to 19 feet, and decrease the danger to navigation more than 500 per cent.

The Rhine and Maas rivers, on entering the lowlands of Holland, divide themselves into many different branches; some winding and flowing back into the main streams, and some feeding on the North Sea and entering through different mouths. In the original improvement of the rivers nearly all the channels were diked, and outlets constructed so as to lead out or in the flood waves during high rises. But the practice of the modern engineers has been to close all the outlets and compel each river to carry its own water. It has been found that this practice causes much less dike breaking, and renders the ice gorges on the Rhine less frequent and dangerous than under the old outlet system.

The levees along the lower basins of the Mississippi may not be high and strong enough to hold the high floods, but if they can not hold with the St. Francis Basin closed, they certainly can not with it open, and require strengthening from different causes than the closing of that basin.

Very respectfully submitted. S. A. MARTIN.

I fully concur in and indorse what Judge Martin says in this paper in regard to the St. Francis Basin, and respectfully ask to be allowed to file it with you, gentlemen, for your consideration.

Respectfully,

JOHN B. DRIVER,
President St. Francis Levee Board.

UNITED STATES STEAMER MISSISSIPPI,
New Madrid, February 3, 1898.

The MAYOR OF NEW MADRID. We desire to call your attention to our harbor, and to the fact that Congress has appropriated considerable money for improvements here, and still our bank is unfinished. The commission has, I believe, recommended that we have a further appropriation of $50,000. We desire this committee, after examination, if they feel we are justified in having that much, to make a further recommendation of that kind. Our town is being washed into the river very rapidly, and at the end of this revetment it is cutting worse than ever.

Examined by Mr. NELSON:

Q. Your harbor is protected by revetment in front?—A. In part.

Q. You are in a bend on the river here?—A. Yes, sir; and we are partly protected by the work of the Government, and we want to ask further protection.

Q. This revetment is of willows and rock?—A. Yes.

Q. And you say it is proving insufficient because the river is getting behind it at the lower end?—A. The work has never been completed.

Q. What is the length of the revetment?—A. I am unable to state. About 1,700 feet, I think has been completed, but not nearly what constitutes the reach of New Madrid Harbor.

Q. Your complaint is that it has not been extended long enough?—A. The reach has not been completed. Hardly half the work has been completed, and we have been receiving money in such small amounts that it has been very expensive to get the fleets here, and it has cost a great deal of money to get ready to do the work.

Q. It has been done under the commission?—A. Yes, sir.

Q. What engineer has been in charge here?—A. I do not know the engineer in charge now—Lieutenant Patrick. It has received in different amounts about $45,000. It has been $10,000, $10,000, and $15,000, and it takes a great deal of money to get the fleets here—three or four thousand dollars.

Q. You say there is a great deal of danger of your town being undermined by the river?—A. Below the town there is an eddy forming, and it is caving, which can be readily seen when the water is a little lower.

Mr. VEST. Well, it is only a question of whether a river and harbor bill is passed at all. You are right that the commission has recommended $50,000; and you require, as I understand it, about 1,200 feet more work.

The MAYOR. Yes, sir; that is about it. We feel that a further recommendation from this investigating committee would probably cause the House to put that amount in the bill.

Mr. VEST. Well, under the resolution that we are acting under, we have nothing to do with that.

The MAYOR. Sometimes people do things that they have nothing to do with, and it costs like everything.

Mr. CATCHINGS. Has the work been successful so far as it has been done?

The MAYOR. It has been very successful.

Mr. NELSON. It has been done lately, has it not?

The MAYOR. The last of the work was done a little over a year ago.

Mr. NELSON. They have used these latest and most approved willow mattresses, have they not?

The MAYOR. Yes, sir; and sunk them with rock.

Mr. NELSON. I would like to have a statement from Lieutenant Patrick, who seems to be in charge.

Examined by Mr. NELSON:

Lieutenant PATRICK. This is in my district, and I have charge of a portion of it. I hardly know exactly what you wish, Senator. The revetment of the place is about 2,100 feet long. New Madrid is right at the head of this bend, and the current coming directly up, as you can see, was eating into the bank and rapidly undermining the town front, and so Congress saw fit to make an appropriation for protecting it, and with the money so appropriated 2,100 or 2,200 feet of revetment has been put down, and is holding perfectly; there has been no caving or damage to it. Below that, from 1,200 to 1,500 feet, the bank is caving very rapidly. I examined it last June at low water, and saw how fast it was going into the river. If protected by the appropriation that these gentlemen ask for, there is no doubt the caving will be stopped.

Q. And you regard that as necessary and essential?—A. I regard it s essential to the protection of the town front, beyond question.

Q. And you think it will take about $45,000?—A. It will take in the neighborhood of $45,000 or $50,000 to finish the work as it ought to be done.

Mr. GALLINGER. What have you to say to the suggestion made by the mayor, that from $5,000 to $10,000 has been appropriated from time to time, and that it would take $2,000 or $3,000 to get your machinery in operation.

Lieutenant PATRICK. I fear I would have to contradict that slightly. If but $5,000 were appropriated for New Madrid, I doubt very much if we would attempt to do anything. These appropriations never came in so small installments as $5,000 or $10,000. The least appropriation was $16,000, and with that they protected quite a large portion of the banks.

The MAYOR. Approximately, what does it cost to get the fleets here and ready for work?

Lieutenant PATRICK. A very liberal estimate to get everything in working order—$1,000 would cover the expense, beyond question, and, in all probability, if work was being done elsewhere and we simply had to transfer the plant here $500 would cover it.

The MAYOR. Then, I am sorry I made the mistake, but I was informed by the engineer that it took $3,000 or $4,000 to get the machinery in working order.

Lieutenant PATRICK. I think you have been misinformed.

Mr. S. BARNES testified as follows:

May it please the committee, it is shown by the Spanish surveys that within the last one hundred years there has been removed by the action of the water, by erosion, over 6 square miles of earth, measuring from the deepest part of the river to the top of our bank. This revetment prevents the caving of our banks, so much so that it would prevent the formation of bars and protect this section of country greatly from overflow. It is the formation of bars and the choking up of the river that helps overflow our country, and the Government is expending great amounts of money on this Point Pleasant Bar, and most of the sand and dirt that has collected on the bars below here in the last few years since I have known the river—and I have been on the river since I was a boy 12 years old; I know this river well—has been taken away from this bank and carried down this side of Point Pleasant and forms that great bar. If this erosion is prevented, which it can be by this revetment, it would be one of the very best investments that the Government could make.

Mr. NELSON. You think, then, that a large portion of the material that has made the bar below has come from the erosion of the bank in front of your town?

Mr. BARNES. Yes, sir; unquestionably so.

Mr. NELSON. And you think that this revetment would not only protect your harbor, but also indirectly affect this bar below?

A. Yes, sir; and give us a better channel.

Rev. J. J. FURLONG testified as follows:

I have resided here for nearly nine years. As a clergyman I have attended meetings along this river, and I have observed somewhat the influence of floods and the necessity of protecting banks. I agree with Mr. Barnes that the material that is washed away from the shore here

does a great deal to form these bars south of here. I noticed when the great war vessel passed up here a short time ago on its way to Cairo that the officials on it reported that they found the most shallow place between New Orleans and Cairo at Point Pleasant, 12 miles south of here. The river, owing to the great width, of course made a very shallow channel, and the war vessel reported that that was the most shallow place between New Orleans and Cairo. That was owing largely to this bank here cutting away so rapidly. The map of this county shows that the bank has caved away here several hundred yards, and of course, naturally, that forms these bars and is a great obstruction to navigation. By protecting the harbor here with this revetment I believe we will save our town. New Madrid has been lost several times, totally lost, in the river, and until the Government made this appropriation we had in many cases to have two parcels of land, one parcel for the building, and another parcel to care for it in the future——

Mr. NELSON. For moving to?

Mr. FURLONG. For moving to. And we did the same thing for church purposes. Then in building a school I took it out a long distance, with the object both of having it safe for at least many years, and also so I could move what church buildings I have now to that.

New Madrid is known in St. Louis and by the press throughout this country as a city on wheels, owing simply and solely to the caving banks here. And you might say I speak in the name of every person in this company here when I say I would be very grateful if the committee would raise their voice for an appropriation by Congress. We request that they give us $50,000, and I am glad that Lieutenant Patrick says that amount would complete the work here. I think it would be wise for the Government to complete the work it has begun. It has spent the money that has been appropriated for this place, and it has encouraged us wonderfully. Our paper recently said that we had erected $40,000 worth of new buildings. We have erected here two brick schools, and we would not have those brick schools at all, in my opinion, except for what the Government has done and our hopes in its wisdom and the wisdom of our lawmakers in carrying on the work and completing it. So we have two brick schools (which will be dedicated next Tuesday) costing in the neighborhood of $7,000, and if the work shall be completed we shall have a substantial town.

Another thing that I would like to mention (as I understand this committee is to consider the question of floods) is that when we have these floods, immediately after the fall of the waters our banks cave very much.

Mr. NELSON. That is owing to the saturation of the banks during the flood, I suppose?

Mr. FURLONG. Yes; and to the loosening of quicksand formation, I should judge.

Mr. NELSON. How did the flood a year ago affect your town? Did you suffer very much directly?

Mr. FURLONG. Not very much, Senator. Business was somewhat suspended, and our schools were closed for a while. Most all of our people stayed at home, and we had water throughout the streets to the extent of probably 6 inches, and in low places in the town we had water 2½ feet deep.

Mr. NELSON. Was that water that filtered through or was it because of some crevasse?

Mr. FURLONG. Some of the water was from the river directly; came right over the bank. First it filled up the gutters, and then, as the river rose, it filled up the streets.

r. GALLINGER. Mr. Mayor, what is the population of your city?
he MAYOR. About 2,000.
r. GALLINGER. Have you any manufacturing industries here?
he MAYOR. Only a sawmill and a flouring mill.
r. NELSON. New Madrid is a very old town, is it not?
he MAYOR. Yes, sir.

ON U. S. S. MISSISSIPPI,
Near Memphis, Tenn., February 4, 1898.

OBERT STEWART TAYLOR, sworn, testified as follows:

Examined by Mr. NELSON:

. You are a member of the Mississippi River Commission?—A. s, sir.

. Will you please state to the committee when the commission was t established, its organization, duties, and mode of doing business?—The commission was created by act of Congress in 1879. By the ms of the law the commission consists of seven members, of whom ee are to be appointed from the Engineer Corps of the Army, one n the Coast and Geodetic Survey, and three from civil life, of whom shall be civil engineers by profession. The commission, as orig- lly organized, consisted of Gen. Quincy A. Gillmore (president), n. C. B. Comstock, and Col. Chas. R. Suter, from the Engineer Corps; f. Henry Mitchell, from the Coast Survey; Capt. Jas. B. Eads, Maj. M. Herrod, and Gen. Benj. Harrison, from civil life. General Har- n was elected to the Senate in the winter of 1880–81, and resigned m the commission on March 3, 1881. I was appointed to succeed him.

. Do you refer to ex-President Harrison?—A. Yes, sir. In the il membership there have been but few changes. Captain Eads igned a short time before his death, and Gen. W. Ferguson, of Mis- sippi, was appointed in his place; and later Col. Henry Flad, of St. is, was appointed to succeed General Ferguson. Professor Mitchell igned from the Coast Survey in 1892, and was succeeded on the mission by Professor Davidson, of California. Professor David- 's residence made it impracticable for him to give attention to the ies of the work and he resigned, and Prof. Henry L. Whiting, of Coast Survey, was appointed in his place and held the office until died, a year or two ago, when Mr. Marinden was appointed in his d. There have been more numerous changes in the membership n the Engineer Corps.

. Who appoints the members of the commission?—A. The President he United States.

. Is there any particular term of office?—A. No.

. It is indefinite?—A. Indefinite.

. When was your colleague, Major Harrod, appointed?—A. He was of the original members.

. He has been on the commission from the beginning?—A. Yes, n June, 1879. He is the only member now in office who was a mem- of the original commission.

r. GALLINGER. Are you through stating in regard to the changes he membership of the commission?

. I have given you about all. General Gillmore remained in office il he died, and he was succeeded by General Comstock, who ained in office until he was retired under the law, and was suc- led by the present president, Colonel Gillespie.

. How many army presidents have you had since the organization

of the commission?—A. Colonel Gillespie is the third. The commission has an office in St. Louis. There the secretary carries on the business of the commission under the direction of the president.

Q. Let me ask you in this connection whether you have always had an office in St. Louis?—A. The commission has always had an office in St. Louis.

Q. And you also have had an office in New York?—A. The president has his office in New York.

Q. Has that always been the case since the commission was organized?—A. That has always been the case since the organization of the commission.

Q. The president has always resided in New York?—A. The president has always lived in New York and had an office there. The duties of the commission comprise the survey of the river in addition to works of improvement. That survey comprises not merely the survey of the river itself, but the taking of numerous observations, the maintenance of gauges, observations relating to discharge and overflow—all of the numerous phenomena connected with the life of the river. The surveys are reduced to maps, which are published in three different forms—three different sizes. This requires a considerable body of experts, who are under the charge of the secretary. The office work in connection with the surveys is done at St. Louis. The president of the commission has always had an office in New York, and the general executive direction of the work proceeds from his office in New York. It has been the habit of the commission to make two inspections annually of the works on the river, going down the river in the spring and again in the fall. These trips have not been made with entire regularity; they have been omitted sometimes, but that has been the general rule. These trips are utilized for business. The commission is provided with a comfortable boat, and the time is occupied in the transaction of business, usually very industriously. Besides these meetings on the boat, there are meetings held upon the call of the president, sometimes in St. Louis and sometimes in New York. In the early days of the commission those meetings were more frequently held in St. Louis, but in later days they are more frequently held in New York. We have at least two such meetings annually, and sometimes one or two more. A considerable part of the business of the commission is transacted through the mail. When questions arise between meetings, in respect of which the president would like to have the judgment of the other members of the commission, it is not uncommon to make up a statement of the question and send it around by mail successively to the members. Each member expresses his opinion in writing upon the subject, and it goes back to the president with indorsements containing the individual views of each member.

Q. When you consider questions upon which you are not unanimous in your views, how do you decide the course to be taken?—A. All questions are decided by a majority vote. When a question arises which seems to require conference, the president calls a meeting at any time. Such meetings have been called occasionally, even within a very few weeks after the holding of a regular meeting. The commission come together as a body just as frequently as the exigencies of the work seem to require it.

Q. What is the compensation of the several commissioners?—A. The civil members of the commission receive a compensation of $3,000 a year.

Q. And expenses?—A. And expenses. The members from the Engineer Corps and the Coast Survey receive no compensation in addition to their regular salaries.

Do they receive their expenses?—A. They receive their expenses; no other compensation than their salaries. As I stated, by the law commission is charged with two different kinds of work. One relates ie survey of the river; and that, as I said, is carried on directly by commission through its secretary, and the money which is expended that work is expended directly by the commission, through its etary.

. As an entirety, without any division?—A. As an entirety, with- any division. In the early days of the commission these appropri- ns were separate. There was an appropriation, usually of about 0,000, for the general work of the commission, and the other part he appropriation was made for the improvement of the river. But ater years that form of appropriation has been changed, and usually, a number of years past, the appropriation is one lump sum, covering work of the commission in its surveys and the work of improvement.

. But in reference to surveys, Judge, you have not been in the habit pportioning that by sections or reaches?—A. No; after the passage he appropriation bill, just as soon as the commission can get hold he bill, a meeting is held and a certain proportion is allotted to the k of surveys and the general work of the commission. The remain- is divided among the works of improvement which are covered by bill. A certain portion is allotted to the construction and repair of es, a certain other portion to works of improvement in the channel his place and that place. These allotments are made by the com- sion in large lumps, I might say.

. And in reaches?—A. We divide them up among the different parts he river. The work itself on the lower river is not done by the mission. The Chief of Engineers details officers of his corps to do work. The river is divided into districts and an officer is put in ge of one or sometimes two of those districts. The expenditure of money is made by that officer. He makes the contracts, disburses funds, and makes report to the Chief of Engineers, not to us, of his enditures. Our function is limited to the preparation of the plans which the work shall be done, and the officers receive those plans us and do the work in accordance therewith.

. I understand, then, that the plans are prepared by you, or under r direction; you let the work, allot the money, and the actual work one by engineers under the War Department?—A. Yes; just as igh the commission had nothing at all to do with it. All the formal- of expenditure and report, and all that sort of thing, are observed ctly as if the commission had nothing to do with it. The engineers harge make their projects for the work and submit them first to the ident of the commission, and he sometimes lays them before the mission. If they are fundamental projects, large projects, he always them before the commission and they are discussed and approved he commission. Projects of a more detailed character are approved he president without being laid before the commission.

. The difference, then, between the method in which the local engi- s operate within your jurisdiction and the engineers on other works at in one case the War Department, through the Chief of Engineers, cts the work and in the other case you direct the work?—A. That early so; not quite. The Chief of Engineers has a supervisory er over the commission. The projects of the engineers are first roved by the commission or its president, as the case may be, and go to the Chief of Engineers and are approved by him. The Chief ngineers can disapprove of them if he wishes.

. He may veto your programme?—A. Yes; he may. He does not

often do it, but he can do it. It is always subject to his a
finally. The work of the Mississippi River Commission really
origin in the Eads jetties. The successful completion of the jett
demonstration which they afforded of the possibility of scour
channel across a bar by concentration of the flow, excited the
the minds of the people that that same principle might be ap
the improvement of the entire river. And there is a great sin
between the bars of the river which obstruct navigation and t
at its mouth. As the river flows down through the valley it flo
a very unequal velocity. In going around bends it flows with
velocity and picks up and carries along a large quantity of sedi

In crossing the river at the head of the next bend it loses a
its velocity and so drops a portion of its load, precisely as it doe
mouth when it comes in contact with the water of the Gulf.
was thought that if some means could be devised by which the
the water across a bar could be increased in velocity by concen
the same effect might be obtained there that had been obtained
mouth, and that in that way a channel for navigation might be ob
Mr. Eads himself was very strongly of that opinion. Upon the
zation of the commission he was made one of its members. H
man of very prevailing force of character. The commission's
report, in which its plan was set out, was, I have been told (I
present at that time), very largely his plan. The essence of t
was, first, to control the low-water flow of the river by restricti
low-water channel to a width of about 3,000 feet across the bars,
that way scour out bars and secure a greater depth for navigati

This was to be accomplished by a twofold work, consisting o
ments of the banks on one side, which would protect them from
and contraction works on the other side, which would build up a
banks and so contract the channel of the river. The contractio
were to consist of structures known as permeable dikes, made
of rows of piles driven into the sand, through which brush an
were interwoven so as to make a very open kind of basket work, t
which the water would flow, but which would serve to dimi
velocity, and so cause it to drop its sediment after passing thro
obstruction. The revetment work was to consist of brush mat
covering the under-water slope of the bank from the edge of lo
down toward the center of the channel, and riprapping of so
from that point up to the top of the bank. For the control of th
water discharge, levees were proposed. It was considered t
entire control of the river required that not only its low-wat
should be controlled, but also its high-water flow, and that these
be made to coincide as nearly as might be. That plan was ap
by Congress and an appropriation of $1,000,000 made in 1881 t
the work.

The following year there was a large appropriation made—$4,
is my recollection. Under this appropriation the work was beg
large scale. The engineering works were highly successful at th
ning. The method employed was not new. It has been pract
other countries and in other parts of this country. There had
successful application of revetment and contraction works on Ho
Bar, a few miles below St. Louis, which had then been in prog
several years and had yielded very satisfactory results. At th
the contraction works had played a large part. There was
great area of land about Horse-tail Bar which was entirely rec
The bars were built up to the level, or about to the level, of t
cent banks. The work that was begun on the Lower Mississipp

was modeled after that very closely. It was found that the contraction works produced the expected result. The deposits of sediment were very rapid and very extensive. A good many acres of land were reclaimed, built up above the ordinary flood line, and are now covered with a heavy growth of timber.

A great deal of land that is now pretty well timbered was made by the commission in its early days by these works. The original plan contemplated mattresses about 125 or 130 feet wide, but they were found to be too narrow. The scale upon which the forces of the river operate here is very much greater than had been encountered anywhere else in any of these works, and the mattresses were gradually widened, but still they failed in many instances. There was a great deal of trouble with the revetments. They are liable to a great many kinds of accident. Sometimes they would fail by reason of the very soft and soluble character of the bank upon which they were placed. Sometimes the bank was of such fine and soluble sand, intermingled sometimes with a very soft sort of clay, that the bank would melt behind the revetment, come out through it like a fluid. Sometimes that result was produced, or at least very much contributed to, by the existence of ponds of water in the flats behind the bank which were left there when the water went down, and which formed subterranean channels to the river, the water emerging through the bank and behind the mattress. And at some points the attack of the river upon the mattress was so tremendously violent that the water would erode the bank through the mattress.

The problem proved to be a very difficult one, indeed; but the commission and the country were nevertheless encouraged by the manifestly good results of the work. At the beginning the work was confined to two reaches of the river, which were selected because they were the worst or among the worst reaches on the river. One of those reaches was at Plum Point (through which we have just passed), some 75 miles above Memphis. The other was at Lake Providence, about the same distance above Vicksburg. In both of those reaches the channel showed a very prompt and very great improvement as the result of these works. In a very few years the bars were removed, so that boats had no difficulty whatever in passing through; and I may say, with very little exception, that the channel through the main part of both reaches has remained good continuously up to the present time, and is now navigable even in the lowest water. After the work had been in progress a few years, and after the revetments had shown themselves to be very difficult of maintenance, there was an objection raised to them, to which Mr. Eads himself contributed the influence of his great name. Mr. Eads, for some reason which I never could entirely understand, came to the view that the best means of securing the narrowing of the waterway was by contraction works, and not by revetments; and under his influence, I think, largely—although I perhaps ought not to speak confidently upon that subject—there was quite an active public opposition to revetments, which seemed to rest to some considerable extent upon Mr. Eads's judgment, and as a result the commission was forbidden by law to make any revetments at all, and that prohibition continued in force, I think, for three years.

Q. When was that prohibition made?—A. I think it was in 1884, but I am not certain about the date. It was somewhere in the neighborhood of 1884 or 1886.

Mr. CATCHINGS. I am quite sure it was 1886. It was after I went to Congress.

The WITNESS. It was probably in 1886. That resulted, of course, in

a great loss of work. A large amount of revetment work had been done, which was practically lost in consequence of that suspension of the work. A revetment in a bend is a character of work which requires constant care and watching. If the river begins to flank it at the top, get behind it, or to attack it anywhere along its line, if the attack is not immediately repelled by suitable repairs, the whole revetment is liable to go in a very short time and a great deal of work be lost. The other members of the commission and all the engineers of the country who gave attention to the subject, I think, were satisfied by further experience, not only that the revetment works could not be omitted, but that they constituted the key to the whole situation; that without them nothing could be done at all. It proved to be of no avail whatever to build contraction works on one side of the river, if the river were disposed to attack the other side, and leave the other side open to attack. The river would simply shift itself laterally, out of the way of the contraction works, and make a new channel.

Q. It would eat in on the other side?—A. It would eat in on the other side. So that prohibition of the law was removed, and from that time on the value of revetment as an engineering expedient has steadily grown in the minds of all persons connected with the work, and the value of the contraction works has relatively diminished in estimation until I think I may say it is the judgment of all of the engineers on the commission, and of all of the engineers who have been familiar with the work, that the contraction works are of comparatively little importance; that the occasions when they are necessary are few. There are certain conditions under which they are necessary, especially where the river, flowing down through a reach of unusual breadth, is disposed to divide itself into several channels. In such a situation as that it is often necessary to close up all the channels but one, and that can be done sometimes only by contraction works properly so called, as where the difficulty lies in the presence of a very wide bar which is entirely covered with water at a high stage. In such a case as that it is necessary to take measures which will not only close the shifting channels across the bar, but build up the entire bar, or a large part of it, to the ordinary bank height.

In that way the work progressed for a number of years. As it progressed the importance of the revetments, their absolutely indispensable character in the work of improvement, became more and more obvious, and at the same time the difficulty of building and holding them became more and more serious. To meet those difficulties the character of the work underwent a progressive change through a number of years. The nature of the work was such that only experience could show what it was necessary to do, and that experience could be gained only through a long lapse of time. The fact that a revetment built with the utmost care would survive one flood was an encouraging circumstance, but only a small circumstance. The experience gained during one flood does not amount to much. The behavior of the work must be tested through another flood, and another and another. At the same time the highest possible success of a revetment in one bend, for ever so many years, did not amount to much. The behavior of the river differs in one bend from its behavior in another. It has been within our experience to build an expensive revetment in one bend and hardly get done with the work—hardly get away with the machinery—before the river would change its mind and quit attacking that bend, cover up the revetment with sand and attack another bend. On the other hand, we have built revetments which have been exposed to the most persistent

and violent attacks, year after year and year after year, the river apparently being determined not to let it alone, and maintaining its attack through a long series of years. These different conditions, the unaccountable variations in the behavior of the river, the differences of soil, situation, etc., presented such a complexity of circumstances that we could not rely with confidence on experience in one place, or one bend, or for one year. We could not rest conclusions upon any other ground than a wide experience covering a wide variety of circumstances and continued for a long time.

As the work went on from year to year the subject was studied from every point of view. A record was kept of every piece of work, of its date, of the precise manner of its construction, and of all the accidents that happened to it afterwards. The works were examined by means of soundings, by divers, and in every way we could examine them, to get at the facts and the reasons of failures when they occurred, and the experience has been just as varied. There are some revetments which have been in use ever since the organization of the commission which have withstood attacks during all those years, and which are still in good condition. The revetment at Delta Point, just below Vicksburg, has been holding its ground for nearly twenty years, and has held a very important point at that place. The revetment at Hopefield Bend, just above Memphis, which is the key to that harbor, and which it was absolutely necessary to put in and hold in order to save the city of Memphis from the encroachment of a sand bar along its levee, and which was a very difficult revetment to make, very difficult, indeed, has held its place and been doing its work for ten or twelve years. And in other places the revetments have been signally successful. There is a place on the Yazoo front, opposite Lake Bolivar, where a revetment was made to protect the levee line. At that place the levee was located between the river bank and an extensive lake which lay behind it, and the bank was caving rapidly in front of the levee. To have allowed the caving to go on and cut into that levee would have made it necessary to abandon that whole line and retreat to another location east of Lake Bolivar, which would have made a very expensive piece of work and would have thrown out a very large area of valuable country. A revetment was built there about ten years ago, which has done its work perfectly; it has held the bank and protected the levee. There are other revetments along the river which have done their work perfectly.

As a result of this experience the methods of construction of revetments underwent a gradual and progressive development, until at last the commission reached what is regarded, I believe, as good a form of revetment as can be projected. I do not think anybody connected with the commission suggests that any further improvement can be made in the mattress revetment. There are some other forms of protection suggested, but so far as the mattress revetment itself goes I do not know that it is considered to be open to any further improvement. As now made, the mattress is composed of fascines, consisting of quite small willow brush laid in line, one brush overlapping the other, until there is made a roll 300 feet long and about 12 to 15 inches in thickness, bound in various parts by a strong wire, and which, when completed, is a good deal like a roll of wool on a large scale.

Q. How do you weave those mattresses? What is the woof?—A. A great variety of combinations have been used. But in this one I am now describing the woof is substantially heavy wire, although that is reenforced at intervals along the mattress, lengthwise, by strong poles

which are wired to the mattress itself. These fascines are built on a boat, each fascine being the full length of the boat, or width of the mattress, and as it slides down on ways which lead to the water it is bound to the edge of the mattress which precedes it, the principal element of connection being, as I said, wires, although in addition to the wires there are poles at intervals which are bound to the fascines. In some of the mattresses, I don't know that I can say all, these connections consist in part of bronze wires which are not subject to oxidation, and which will hold, you may say, permanently. The other wires are galvanized steel.

A great many observations have been taken as to the life of that form of connection. Old mattresses have been pulled up and the wires have been examined. My own judgment is that we have no reason to believe that any of our mattresses have failed by the giving away of their connections after they have been placed in position on the bottom. When the mattress fits its place on the bottom of the river it is subject to a deposit, usually of silt or sand, and is likely to be quite firmly embedded in the bottom of the river. The cases are rare, I think, in which it is torn away from its place by the current flowing over it. The damage which the water does to a mattress which has been put in position is usually at its lower edge in the way of undermining it below, so that the edge drops down. And one of the points which it has been found necessary to care for very particularly is to build the mattress of such flexible material that if the water undermines its foot it will fall down and keep snug to the bottom. And for the purpose of insuring that result, in a great many cases—I think generally—in building the mattress there is a sort of pocket made along the outer edge which is filled with stone so as to make the outer edge pretty heavy so that will immediately drop down if the water begins to undermine it, and so keep its lower edge snug to the bottom. I think I may say that with such a revetment as I have described a 300-foot fascine mattress covering the underwater slope of the river from the edge of the low water down, with a heavy stone riprap above, any bend on the river can be held. The undertaking is a feasible one from an engineering point of view. I believe that has been demonstrated. It has also been demonstrated that it will cost not less than $30 a foot to do it.

Q. Thirty dollars a foot running down the river?—A. Running down on the river. When we began the formation of revetments, they were made at a cost of about $12 a running foot. In developing improved forms the cost gradually increased, dollar by dollar, from about $12 to about $30 a running foot. There are some localities where the cost would exceed $30, and some, perhaps, where they would cost a little less; but, as an estimate for the river at large, I think we may count upon $30 a foot.

Another fact became manifest in the course of the work—not as a revelation, for it was foreseen when the work was begun—and that is that it is impossible to effect a permanent improvement of the river in detached places. The river is constantly making, or liable to make, changes in the curvature and location of its bends anywhere, and its behavior at a given bend is affected directly by its behavior in the next bend above. A change in the contour of the bank in one bend immediately changes the direction of flow by which the river enters the next bend below. So that, if you improve one bend, and leave the bend above unimproved, you are liable in a few years to find that the entrance of the river into the improved bend has changed, and that, in consequence, the impact of the current upon the bank has changed, and the

work done is altogether out of adaptation to the conditions. It follows that for permanent work we must begin at the upper end of the river or at some place from which we can be sure of a permanent entrance of the current into the improved reach. That difficulty was found to be a very great one in the Plum Point and Lake Providence reaches.

The commission realized that truth when the work was first begun, and I have no doubt that if there had been no considerations to be taken into account, except the most logical and scientific way of beginning and conducting the work, it would have been begun at or above Cairo, where the alluvial valley begins. But there were other reasons which controlled. It was desired to test the system in a way which would give early results in benefit to navigation, and Lake Providence and Plumb Point were among the worst places there were, and it was thought highly desirable to start an improvement in those places, if possible, as soon as possible. Of course, the full difficulty of the work, the time which would be occupied, and all that, were not adequately understood at the time. It was supposed that three or four years at the utmost would be all that it would be necessary to consume before the work would be complete in those reaches, measurably, and we would be ready to begin in others, and for years the commission was looking forward to the early commencement of work at New Madrid and other points on the river, where there was also bad navigation.

Mr. VEST. Do I understand you to mean that it was the conclusion of the committee, and that they believe now, that this work ought to be commenced on the upper part of the river instead of the lower part of the river?

A. The revetment works ought to be begun at the upper part of the river, in my opinion.

Mr. VEST. Then you do not think that the river ought to be improved from the mouth up, but from Cairo down?

A. Not so far as the revetment works are concerned. A different statement is to be applied to the levee works. Under existing conditions the work of building levees must begin at the lower end and progress upward, but the logical way of building the engineering works is to begin at the upper end and progress downward.

As this experience went on it began to become apparent that the improvement of the low water-channel for navigation—that is, the securing of deep water over the bars by means of these engineering works—was an undertaking of so much difficulty, and that the time which must necessarily be consumed before a complete improvement could be reached was so great that the necessities of commerce could not be met in that way. Entire success was attained in Lake Providence and Plum Point reaches in the improvement of the channel, but the navigation of the river as a whole was not very much helped; it was not of much avail to give the steamboats a good channel through two reaches, 20 miles long each, and leave the bars elsewhere unimproved.

At the beginning of the work I suppose no engineer in the world would have thought of undertaking a general improvement of the Mississippi River channel by dredging. The dredges that were then known were totally inadequate to work of that kind. I remember saying in an address which I made in 1881, that to undertake to handle the sand in the Mississippi River so as to get a good channel by dredging it would be as impracticable as to cart the water away in time of flood, and it seemed so. But the progress of invention and improvement in engineering machinery brought to light the modern form of

hydraulic dredge, and its possibilities were so immense that the tion of the commission was turned toward that as a possible me: relief. There are difficulties in the way of navigation at the mo Red River which have required dredging ever since the commissi organized, and a great deal of difficulty was experienced in doin work by means of the forms of dredge which had been in use in previous. We took up the subject of hydraulic dredges in conn with that work, and sent an officer (one of the officers in charge of the districts on the river—a very bright and capable young m examine the most successful hydraulic dredging plants in the co and as a result of that study he designed a dredge for use at the of the Red River which has proved to be one of the most suc and efficient pieces of machinery that I ever saw. It apparently the problem at once. There has been no difficulty in keeping the of the Red River open since we put that dredge at work.

Examined by Mr. CATCHINGS:

Q. And with the old-fashioned dredge you were unable to ke channel open?—A. We only succeeded once in a while.

Q. But with the hydraulic dredge there is no difficulty?—A. never has been any trouble at all with the hydraulic dredge. P it may not be amiss to say that what I mean by hydraulic dre that form of dredge in which the material to be removed is first re to a fluid or semifluid state and then pumped away.

Q. Suppose you briefly describe a hydraulic dredge.—A. The ple of operation of a hydraulic dredge is simply this: The materia dredged is reduced to a fluid or semifluid condition, either by som of revolving cutter, which cuts the sand or whatever it may be in pieces, or else by the impact of a jet of water forced against it by of a force pamp. At the spot where this action takes place is the of a suction pipe, and connected with that is a pump of great and the mingled soil or sand and water is drawn up into the mo that suction pipe and carried to that pump and forced away, u through a long pipe of some kind. The pipe may float on the wa it may be carried up the bank so that the dredged material deposited on the land.

We were encouraged by the success of the small dredge at Red to try further experiments, and the commission built an experi dredge of its own on a larger scale, under the superintendence onel Flad, which was highly successful. From that the comm determined to try the experiment of constructing a dredge of the power and capacity. It was considered that the possibility of effec improving low-water navigation in the Mississippi River by dre depended upon cutting through a bar very quickly and making a nel of which the river could take possession before it would b filled up with sand. With that in mind, we corresponded with ber of the most eminent engineers in that line in the countr brought three of them before us, and went over the subject with thoroughly and in detail. We finally made the proposition to that each one should submit his plans for a dredge, which shoul a capacity of taking up and removing to a distance of a thousan not less than 1,600 cubic yards of sand per hour, we to consider plans and award a contract to whichever one of them appeared to make the best offer, taking into account not merely the price b plan of construction. It was also part of the agreement that t cessful bidder should have a bonus for the output of his dre

excess of 1,600 yards per hour, proportional to its contract price, and not to exceed 50 per cent of that sum.

Mr. NELSON. Over and above the minimum fixed?

A. Over and above the 1,600 cubic yards per hour. It gave the contractor an opportunity, by building a dredge that would handle 2,400 cubic yards per hour, to get 50 per cent additional on the price. The contract was awarded to Mr. Lindon W. Bates, of Chicago, and he built a dredge which was phenomenal in its capacity. By the terms of the contract the dredge was to be subjected to a series of tests by measuring its output in a barge. Mr. Bates's dredge showed on an average, I think, of ten tests, an output of something over 4,000 cubic yards per hour upon the official tests. Those tests were no tests of its capacity in regular work. I do not think anybody supposed they were at the time; at least I did not.

Mr. VEST. You mean it was too much?

The WITNESS. Yes, it was more than could be done in regular work. That test was made under the supervision of the contractor and with trained experts, and he had prepared himself in every respect in the construction of his machinery and everything about it, so as to accomplish the highest possible result for a little while. But, with all allowance to be made for that, it was manifest that that dredge disclosed great possibilities. It disclosed the fact that it was possible to build machinery which could be floated on the river, by means of which the sand could be removed with great rapidity—a greater rapidity than most people had previously conceived to be possible at all. That dredge was as constructed subject to some defects. The contract required that its draft should not exceed 4½ feet, and it did in fact reach, I think, something near 6½ feet—from 6½ to 7 feet. And there were some other imperfections about its machinery. It required numerous repairs after it was set to work. The final result was that the engineers of the commission considered that, while the dredge had answered the purpose of its construction, which was to determine experimentally something about the limits of possibility in that kind of work, it was not the best form to build and to use for actual operations on the river. Since that time four more dredges have been built and one or two more are in course of construction, designed, I believe, to have about half the capacity of that one. And I suppose that is a better form of dredge than one so very large. The *Beta*, though, the large dredge, has done some remarkably good service. It has shown its capacity to handle very large amounts of material and to do it very cheaply.

Examined by Mr. VEST:

Q. It could not be used, though, in low water?—A. Yes; we have used it in low water. There has been some difficulty in using it in very low water.

Q. It drew 7 feet, didn't it?—A. In consequence of its excessive draft; and it is proposed to so alter it as that its draft shall be reduced to about 4½ feet. In getting it out for use this last season, it was found impossible to float it over a bar which it had to cross until it dug its own way through, and the work was delayed quite a while in consequence of that difficulty.

Q. What did that dredge cost?—A. The contract price, I believe, was $172,000, and Mr. Bates was entitled to and received his bonus of 50 per cent on that sum; but deductions were made from this sum. A deduction was made for the cost of changing the draft to 4½ feet and for some other things in respect to which the dredge did not con-

form to the specifications. The final settlement with Mr. Bates made by the Chief of Engineers and the Secretary of War, and not prepared to say exactly what it was.

Mr. HARROD. The deductions amounted to $41,000.

Mr. NELSON. From the contract price and the bonus?

A. Yes; from the contract price and the bonus.

Q. What is the capacity of these four new dredges and what i capacity of this first dredge, after the draft was reduced to 4½ fe A. It has not been reduced yet. We have used it so far just as it

Q. These four new dredges have never been operated?—A. Oh some of them have.

Q. Their draft is 4½ feet?—A. Four and a half feet draft.

Q. Now, what is their capacity?—A. The gentlemen here who a the dredging committee can tell you more certainly about that, bu recollection is their capacity is 800 cubic yards, with the excepti one, and that its capacity is 1,000 cubic yards.

Colonel GILLESPIE. I think the first one has a capacity of 80(all the rest 1,000.

The WITNESS. In the prosecution of that work the commissio entering upon an unknown field to a large extent. It was a very d ful question whether it would be possible to open channels throug bars by dredging that would remain open even during a singl water season. It was anticipated at the beginning that success depend very largely upon a wise selection of the channel. The (sition of the river to cross a bar at this place, or that, or the oth a very mysterious thing; and yet the river has a disposition in way, which is a very stong one, and which can not very easily be trolled. And it was foreseen that if we undertook to cut a ch across a bar and missed the natural drift of the current the might not accept the new channel, and that success would pro depend very largely upon striking the right line for the dredging (channel.

Mr. NELSON. In order to get the real thread of the current?

A. In order to get the real thread of the current and the real ten of the river. And that has been proved by experience to be a very cult element, and success has been somewhat varied. In some o work done the success has been unqualified; the river has accepte invitation to take the new channel opened for it and has remaine and deepened and enlarged it. In other instances there has been a bit of trouble. In some instances apparently the wrong place has selected and the river has been rather indisposed to go there. T a feature of the problem that will have to be worked out by e ence, I suppose.

Upon the whole, the results so far have been, to my mind, h encouraging. There are great difficulties yet to be overcome; not the one that I speak of, but another one which is perhaps quite as se and that is to get at the work early enough to have the channel from the beginning. It does not avail to put dredge boats at worl occupy the low water season in making the channel and get it about the time the low water season is over. What commerce wa a continuous channel, and the dredging operations will never be a plete success until we are able to prevent the formation of sh channels at all. We must take time by the forelock and, as the falls, anticipate where it wants to go and keep the channel open necessary depth all the time. We have not got to that point yet. have not been able yet to anticipate the fall to such extent as to

the channel open in advance. We have had in consequence some embarrassment in the way of having our boats at work in the channel at a time when commerce wanted it, and it has been necessary sometimes to stop the work of dredging and get the dredge boat out of the way to let steamboats go up or down. All that, in my opinion, however, will be worked out. I think I see the evidence of permanent success in the work. The channels themselves when open have, as a rule, exhibited a permanence throughout the low-water season, and a disposition to enlarge rather than diminish, which has been highly encouraging; and for my part I believe that it will be possible to afford a channel of not less than 8 feet from Cairo down through the low-water season in that wav, and at a cost which will be a mere trifle compared with the accomplishment of the same end by means of revetments and contraction works.

Mr. CATCHINGS. What needs to be done and to be learned, Judge, to enable you to foretell the directions of the channels and to keep them open in the way you suggest?

A. I can hardly tell. If I could, the problem would be solved now. It is a problem to be worked out, not by engineering science alone, but by a combination of engineering education and instinct. I do not think it can be done by a mere survey and the application of engineering rules to the survey. It must be solved by observation on the ground.

Mr. NELSON. By a combination of the knowledge of the engineers and of the river pilots?

A. Yes, both, with a little besides, which I do not know exactly how to define; a little of that mysterious instinct in man which enables a doctor to diagnose a case, or an inventor to solve a problem, or men in all walks of life to get around difficulties through which other men can not see their way.

Mr. NELSON. The determination of where to excavate a bar so as to get the true thread of the stream is more of an engineering feat, is it not, or do you classify that in the same category?

A. That is what I am talking about. That is not mere engineering, it is partly instinct. It is to be done by observation on the ground. It requires the knowledge and instinct of a pilot and something besides. I would not trust it to a mere pilot, and I would not trust it to a mere engineer. You need a combination of both; your man must be qualified by nature and by experience. I do not think it is to be said that in the work so far done there has been shown a lack of ability. On the contrary, I have been rather surprised at the success which has been so far attained. As a rule, the channels have been made in the right place; the failures are the exceptions. I think the gentlemen in charge of that work have so far exhibited a high degree of ability and have had a high degree of success. But the success has not been absolutely perfect. For my part I did not expect it would be. I expected more difficulty than we have had before we began. As this work has developed itself, as the probable feasibility of providing a low-water channel by this means has gradually grown upon the minds of the commission, there has at the same time grown up the conviction that the attempt to secure this same result by a general improvement of the channel by means of levees and contraction works is one which ought not to be continued.

Mr. NELSON. Owing, to a large extent, to the expense?—A. Yes. Some two or three years ago the commission took up the subject for very careful investigation with a view of presenting to Congress the facts of the situation as they had been developed. Those facts are

embodied in our recent reports. They show that the judgment commission is that for a permanent improvement of the chan navigation the work should begin at the upper end and progress ward consecutively. The cost, at an estimate of $30 per runni from Cairo to Vicksburg, would amount to $60,000,000 at a ve servative estimate, and the expense for the maintenance of th after it had been done would not be less than 10 per cent, and pr more. The commission put it down as a little less than 10 pe which would be $6,000,000 per annum to maintain the revetment Cairo to Vicksburg. In addition to that, the experience of the c sion has shown that there is a limit to the material which obtained for the work. The revetment mattresses are made fron willows. The form of mattress now used, the fascine mattress, r smaller brush than the forms of mattress that were first used. necessary that the mattress should be very flexible for the r which I have stated, and that flexibility can be obtained only use of small brush; and the amount consumed in the construc mattresses 300 feet wide, made of small brush, is enormous. A calculation shows that the entire capacity of the bars on the river be taxed to their utmost for forty years to complete the revetmen Cairo to Vicksburg.

Mr. NELSON. You mean their capacity for furnishing willow Yes; their capacity for furnishing willows. So it would tak years to do the work in that way, if there were no difficulty at all way so far as money is concerned. Of course other material co used. No other which is so good has ever been suggested, and pose no one could think of any which is so good as these small w If we should attempt to use any kind of sawed lumber or try t up the larger willows into smaller pieces the cost would be incr and to do the work in that way would make it necessary to ente an entirely new course of long and costly experiment. In view o facts, the commission in its last report and in the one preceding tl laid these facts before Congress, and, as a result, the work of c improvement by means of revetment has been practically susp None of that kind of work is going on, and none has been going a couple of years, except what is necessary to maintain the already built in Lake Providence and Plum Point reaches. Some has been expended in those reaches in the way of repairs and n nance of existing works. Nevertheless, the work of revetment always will be one of great importance on the river. I do not t exaggerate when I say it has reached a degree of perfection on th sissippi River which has never been approached anywhere else world. There have never been anything like such mattresses laid anywhere else in the world as are now being made on the Miss River. They could not have been made by anybody fifteen year Men did not know how to do it. They could not handle them. very difficult thing to build a mattress 1,200 feet long and 300 fe on the top of the water and load it and sink it to the bottom river in an unbroken and firm condition, frequently in the fa strong current and an accumulation of drift to be watched and care of. I have been amazed at the skill, ingenuity, and reson the engineers in handling those great structures.

There are points where they must continue to be used. For ins at such a point as the bend above Memphis. Unless the Hopefiel revetment is maintained Memphis will become an inland town, from the river by a bar.

Mr. NELSON. You will still have to use that system to protect harbors or bends?

A. Yes; and it will still be economical to do it sometimes in protecting levees. Where there is an important levee situated near a caving bank, and where, in case you should allow the levee to be cut off, you must throw open a large extent of country and go around behind a lake, miles away, to build a new line, it may be much more economical to protect the levee by revetment than to let it go and build a new one. We have such a case at Lake Bolivar, and the commission has recently built a revetment for the same purpose at the foot of Lake Providence reach to protect the levee that lies in front of Lake Providence. At Lake Providence if the present levee were abandoned it would be necessary to go behind the lake with a levee and throw out the town. The Tensas rises in Lake Providence and discharges down the valley, and in order to make the new levee it would be necessary to not only go around Lake Providence, but also to build the levee across the bed of the Tensas, which would be a very difficult undertaking; I suppose not impossible, but very difficult.

Another indispensable use of revetments is for the prevention of cut-offs in places where they would be disastrous.

Mr. NELSON. That is, where the river cuts across bends?

A. Yes. The river has a natural tendency to commit suicide occasionally by cutting off its own neck. As the water flows around the bends they tend to deepen or extend inland, with increase of radius, sometimes with caving at the neck of the bend, both above and below. This action narrows the neck until finally, at some high flood, the water goes across the neck with a burst and abandons the bend. Such a change introduces a disturbing condition in that part of the river which is highly injurious. It may be 15 miles around the bend and only a quarter of a mile across the neck. In such a case the fall of the river around the bend will be, say, 7 feet, and the cut-off therefore introduces a fall of 7 feet in a quarter of a mile, producing a tremendous increase in the velocity for a number of miles above the bend and a number of miles below, and that increase of velocity increases the caving action in all of the bends that are affected by it. So the river goes immediately to work to restore the length which it lost by the cut-off. The length of the river is the result of an adjustment between the velocity of the stream and the resisting power of the bank.

The valley of the Mississippi is composed of alluvial material, which has, you may say, a given power of resistance to the stream. And when its length is such as to reduce the velocity to that rate which the bank can stand, its condition is comparatively stable. If you increase the velocity, you increase the caving action, and the length is increased, until, by increase of length, the velocity is diminished to a point at which the bank will stand the impact. The river is its own engineer. It is like a fat man going down a steep hill. He dare not go straight down; if he should try it he would go headlong directly. He controls his own momentum by zigzagging down, just as a railroad engineer lays out a track down a mountain side. The river zigzags down the valley in the same way, and so, by maintaining its length, keeps its flow within the limit at which the banks can bear the impact as well as they do. The commission has made some careful studies on that subject, and the result is to show that, notwithstanding a great number of cut offs have been made in historical times, which would in the aggregate have reduced the length of the river many miles, the river has still, so far as we can ascertain, substantially the same length that it had a hundred

years ago. And I do not believe that anything man can do would prevent it from having about the same length in the long run. And so it is regarded as of importance to prevent cut-offs in some places—not always, not everywhere, but in some places.

There are two such places on the river now. One of these is at the upper of the three bends which lie a short distance above Greenville. There is at this place a very remarkable succession of bends. The river has been flowing around these bends without change, apparently, for a great many years, and we have in them a very stable channel. A cut-off is threatened at the upper one of these bends. If that bend should go, the two below it would inevitably go in very quick succession. The taking out of these three bends would shorten the river 30 miles at least, and nobody can foresee the changes that would result. They would be enormous in extent, and they would go on for many years. So it has been regarded as an important thing to prevent that cut-off from taking place, and for that purpose a revetment was built there several years ago. It has been doing good service, and apparently is likely to succeed. Another place of the same character is just above the city of Natchez. A cut-off is threatened there immediately above the city which would take out (I do not remeinber exactly) I think some fifteen miles in length of the river.

Mr. CATCHINGS. At Cowpen?

A. Yes. I do not know that anybody can foresee just what would happen, but it is practically certain that one result would be to build up a great bar in front of Natchez and leave that city inland as Vicksburg has been left inland. For the purpose of preventing cut-offs revetments will always be necessary.

Mr. VEST. How about the Atchafalaya, or the mouth of the Red River? Is there any danger of a cut-off there?

A. I think not. The problem presented at the Atchafalaya has a great many sides to it. There was at one time a very keen apprehension that the Mississippi River might leave its channel at the mouth of the Red River and make a cut-off or outlet for itself down the Atchafalaya to the Gulf. I suppose there are conditions under which that would occur. But in anticipation of the possibility the commission a number of years ago made two sill dams across the Atchafalaya River near its head, intended to prevent any enlargement of the channel there. The plan contemplated the building of five such dams, but only two have been built because they have apparently perfectly accomplished the object. In present conditions I do not think any transfer of the Mississippi River discharge down the Atchafalaya is at all to be feared.

Mr. VEST. Senator Caffrey, who lives on the Teche, says there is immediate danger.

A. Well, I do not think it is so. I think if he would go up and look at the work and study its history for the last seven or eight years, he would be convinced there is no danger of that.

Mr. VEST. He says that the flow into the Atchafalaya is increasing all the time.

A. I do not think it is. If it is, it is in a very slight degree indeed.

Mr. CATCHINGS. Have you flood discharges to show in regard to that from year to year?

A. We have. Measurements have been made there from year to year, and if it is not perfectly safe now it is capable of being made so by the addition of one, two, or three more sill dams. A sill dam well made, with levees on each side and with adequate shore protection at the ends of the dam, acts as a perfect restriction of the discharge.

think it is entirely possible to make such a catastrophe absolutely out of the question. I think the works that are there now have done and it and will do it. The commission has been ready all the time to extend those works, and has not done so simply for the reason that there did not appear to be any necessity for it.

Mr. NELSON. How many dredges, in your opinion, of such capacity as the four new ones you have lately built, would be necessary and requisite to maintain a navigable channel at high water, from Cairo to the Head of the Passes, and what would be the cost of such dredges and the cost of the operation and maintenance of them?

A. It has been estimated by the engineers of the commission that a fleet of nine dredges would be sufficient to do the work from Cairo to Vicksburg.

Q. Below that it would not be necessary?—A. Below that no calculations were made, although I think there must be provision made for some work below Vicksburg. Some bars have developed there within recent years that constitute an obstruction to navigation, and one of those bars, known as Fords Crossing, has been operated upon by the *Ram* (which is the Red River dredge boat that I spoke about), and I think it will be necessary in the future to be prepared to do some work below Vicksburg, but the amount will not be very large.

My own impression about it is (although that is a point that other members of the commission are better qualified to judge of than I am) that we ought to have something more than that. I think that, in order to get at the work early enough and prosecute it rapidly enough to keep a depth of 8 feet right along, there ought to be two or three more dredges built and within reach. If I were myself called upon to name the number necessary, I should put it at twelve rather than nine, although our former calculations were based on nine. These dredges cost from $100,000 to $125,000 apiece, according to their construction, and the expense of operating them is about $50,000 each for the season, or a little less than that.

Mr. NELSON. Then ten dredges would cost about a million and a quarter?

A. Yes, sir.

Mr. NELSON. And the annual expense of operating them would be half a million?

A. Yes, sir.

Mr. NELSON. That would be a fair statement?

A. That would be a fair statement; yes, sir.

Examined by Mr. VEST:

Q. Fifty thousand dollars each is the amount allowed for the two dredges in the Mississippi now and one in the Ohio, is it not?—A. There has not been any specific allowance of that kind made. The estimate made by the commission was that the expense for the maintenance of the seven dredges would reach about $350,000 per annum.

Q. But is there not an appropriation?—A. No; there has been no appropriation of a specified sum per annum.

Q. I am very much misinformed, then. My recollection is that there is an appropriation of $50,000 for each of these dredging boats—one on the Ohio, two on the Mississippi, and that there is no appropriation for the dredge boat on the Missouri.—A. I think you refer to snag boats, Senator.

Mr. VEST. Yes; that is so.

The WITNESS. The estimate of the cost of running the dredge boats is about $6,000 per month, so the amount per annum would depend

upon the duration of the low-water season and the amount of work to be done, but I should say that, for all the expense of operation, care, and all that sort of thing, the cost would be within $50,000 per annum for each boat. The commission have now six ready for use and another one in process of construction, and means enough, I believe, to finish it, and that will exhaust the resources of the commission.

Q. You made one statement, Judge Taylor, that impressed me greatly. I noticed in the last two reports of the commission precisely the same statement, although not as strongly as you made it, and that is that it is now the unanimous opinion of the commission that the two instrumentalities to be relied on for the improvement of the navigation of the river are revetment and dredging, and that, save in exceptional cases (where there is a wide bar, for instance), the contraction works need not be used. Am I right about that?—A. You are, so far as the contraction works are concerned.

Q. Now, is that not a wide departure from the original theory on which the improvement of the river was undertaken? For instance, you state (and I have no doubt of the truth of your statement) that the commission originated in the success of the jetty work at the mouth of the river, which was based absolutely and almost entirely on the jetty or contraction system. Now, is this not an abandonment, practically, of the great fundamental basic fact on which all this system was inaugurated and upon which Captain Eads based the claims for his jetty work, which did succeed? In other words, if I understand you (and I do not want to do an injustice to the commission), say you have a bank upon one side of the river which requires revetment; it is crumbling and giving way, and you can only secure its stability or permanence by revetment; you then construct your revetment works. Now, having made an artificial bank there which will resist the action of the water, you have on the other side no necessity for revetment, but do you not still have to contract the volume of water so as to enlarge the scouring power of the river? Why is it, when you have simply revetted one bank of the river, that you give up this principle of contraction?—A. I do not consider that the view the commission has taken of that part of the work is any abandonment of the theory. I think it is in entire harmony with the theory. It is simply a change in detail in respect of the engineering works necessary to accomplish the result.

The river in most cases naturally seeks to flow along the concave side of the bend. There may be a wide space of bar opposite the bank at that point, but in most cases the greatest velocity of the stream is around the concave side of the bend; and if the bank is held against erosion, so that the river is compelled to maintain one path, it will deepen itself and maintain its channel, without reference to the width of the bar which may lie on the convex side of the bend. Furthermore, the difficulty which arises as to the obstructions to navigation consists in the formation of bars at the crossings. The material of which these bars are made comes mostly from the caving of the banks in the bends immediately above. If by revetment of those bends you stop that caving, you cut off the supply of material out of which the bars are made. And if there were a complete system of revetment from head to foot of all the bends, so that the caving would be substantially stopped, the material out of which the bars are built would be to a large extent exhausted. The cases in which contraction works are necessary are those in which the river will not of its own choice take a position next to a revetment. If the situation of the river be such that the river will at one time take a position in one part of its channel, and at

ther time in another, it may be necessary to exclude it from that t of the channel which you do not wish it to occupy. But experi- e has shown that those are the exceptional cases; that the rule is t the river will follow the bend next the caving bank, then cross r and follow the next bend along the bank, and so on down. That he rule. And where that is the case, if you hold the caving bank, can safely let the river do as it likes over the bar.

Q. In other words, you do away with the necessity of any contraction rks, largely?—A. Yes; they are found to be comparatively unim- tant.

Mr. NELSON. You mean opposite the revetment work.

A. Opposite the revetment work they are comparatively unimportant. at is not at all an abandonment of the theory of contraction. Experi- e has disclosed that in order to obtain the contraction you do not ally need the contraction works.

Q. Would it not make assurance doubly sure, though, if contraction uld be added even to revetment? That is to say, is it not always ter to increase the scouring power of the river? You can not have much of that, can you?—A. No.

Q. I am not now arguing against revetment. I believe in revetment, the jetty system, and in dredging, all three of them. And then I nk we have a very difficult problem.—A. Yes; no doubt.

Q. But your statement was very strong, and involved (it seemed to) the reliance of the commission, save in these exceptional cases, on two of these instrumentalities, leaving out the third; in other rds, that you rely upon revetment and dredging.—A. That conclu- n has been reached as the result of experience. Contraction works ve been actually found to be of such secondary importance that it s been considered wise to devote the money to revetments rather than contraction works, as a rule.

Examined by Mr. NELSON:

Q. As I understand, the drift of your testimony is, not that you do t consider in all cases that the contraction system is obsolete, but at where you have the revetment work opposite those works contrac- n work is not necessary?—A. It is usually not necessary.

Q. That where contraction work is necessary is in reaches of the river ere it expands on both sides and does not tend to undermine some rticular bend of the river?—A. Take a condition like this: You have metimes a stretch of river a number of miles long, say 5 or 10 miles ose are rare, but you have some such cases), where the channel is actically straight, and where the width between banks is excessive, may be 2 or 3 miles, and the space is occupied by a broad, flat bar, d the river will at low water sometimes drop into one place in the r and sometimes into another. In such a case as that you must shut e river out of a part of that bar——

Q. And there it is wholly contraction work?—A. There you must ve contraction work.

Q. And revetment work does not enter into the case there?—A. Yes, loes. In such a reach as that your scheme of improvement begins by ing out a new path for the river, which shall embrace normal curves flow. In every such case the object is to make the river crooked; t is to say, to introduce into its channel a curvature which corre- nds to its best flow, to imitate those parts of the river where nature done her best work. A very little study of the Mississippi River ws that those parts of the river which are most permanent, which e the best channel, are those parts where one curve succeeds

another in regular order; and in a long, broad, straight reach the first requisite is to map out a path of normal curvature for the channel. In order to make it take that channel, you must build contraction works on those parts of the bar from which you want to exclude the water, and revetment works in those parts of your new channel where you want to create a bend. And I have always thought that the first indispensable requisite of success in those engineering works was to succeed in laying out a normal path for the river through the disturbed reach. The conditions in such case are precisely like those I spoke of with respect to cutting a channel across a bar. You must give the river a path which accords with its natural laws of flow or you can not do anything with it.

It has always seemed to me, from the time I had been two or three years in contact with the work, that its final success would depend upon success in that particular. I had a hope that through these disturbed reaches the river might be made to assume a normal curvature of flow, and establish itself in such a path, and that it would be content to flow in that channel and quit its attacks on its banks. That is what we find in the best parts of the river. It is not by any means true that the greater part of the channel of the Mississippi River is bad. The greater part of it is good—good all the year round. The obstructing bars are confined to certain places, are mostly found in groups, and their actual length is trifling compared with the total length of the river. And those places where the river follows a symmetrical series of curves, one after the other, are the places where the channel is stable and where the low-water channel is always good.

Mr. CATCHINGS. How many of those bars are supposed to exist between Cairo and Vicksburg?

A. About forty, all together. And the first task of the commission in its work was to study those features of the river, and to try to lay out through these disturbed reaches a curved path that would fit the natural flow of the river. In the Plum Point Reach we appeared to have succeeded in that respect. In that reach the river dropped into the path that was laid out for it, and was apparently contented there, and flowed down that path for many years easily and naturally, and it seemed to me that we had solved the problem there perfectly.

On the other hand, in the Lake Providence reach the river was never satisfied with its channel; it always appeared to me that we had missed it there, that we had not succeeded in laying out a true path for the river's flow. The river in the Lake Providence reach was always attacking its revetments. We got a good channel and kept it, but there was a great deal more difficulty at Lake Providence in maintaining the works permanently than there was at Plum Point. And my faith in the permanence of those works was greatly shaken in later years mainly from the fact that, owing to changes that took place in the river above the Plum Point reach, it began to attack its works in that reach and to exhibit an impatience with the restraint which had been put upon it. I think there is no doubt of the general truth of the proposition that a successful improvement of the river throughout its whole course would depend, fundamentally, upon a wise adaptation of the curvature of the channel to the natural laws of flow which control it; and I never did expect that this kind of improvement would prove a permanent success unless that part of it succeeded. I thought that if we could get the river trained in a line of flow which was in harmony with its own laws it would give up the struggle, and that the works could be maintained within practicable limits of cost and we could secure a permanently improved channel; and I think very much so yet.

Mr. CATCHINGS. Was it ever contemplated, Judge, that there should be any general use of contraction works; or, rather, was it not according to the original plan that these contraction works should only be used in the very wide places, so as to reduce the width to about 3,000 feet?

A. It never was contemplated to use them everywhere. It was contemplated to use them only where it was thought they would be necessary in order to reduce the width to about 3,000 feet. And the only reason a different conclusion was reached was that, as the work progressed and as experience accumulated the contraction works were found to be less and less necessary for that end, and the revetment works were found to be more and more necessary. It was simply a question of the relative importance of the two kinds of work, and that came out purely as the result of experience.

Examined by Mr. VEST:

Q. But there are places where you could use those contraction works?—A. Certainly there are. I think now that if the commission were set to work to improve a place like Plum Point reach, under exactly the conditions which obtained there at that time, that it would put in contraction works; I think it would have to.

Q. You never could have gotten rid of Horsetail Bar without contraction works?—A. I have no doubt of that.

Q. And that splendid piece of work below Jefferson City, on the Missouri River, never could have been done without it?—A. I think that is very likely.

Q. They had to use both contraction works and revetment?—A. But that conclusion, Senator Vest, entered into this work, I may say, mostly in this way: In my estimate for the probable cost of a complete improvement from Cairo down, it was considered that the places where contraction works would be necessary were not numerous and that the expense would consist mostly in the cost of the revetments, and so the estimate that was submitted in the last report of the commission was one based upon the cost of revetment works, and no attempt was made to make a detailed estimate of the cost of contraction works. It was considered that by including in the estimate the cost of a continuous revetment of all the bends that an approximate idea would be obtained of the probable cost of the work.

Q. Now do not understand me, Judge Taylor, as objecting to revetment. I appreciate the reasons for it. But I must say it seemed to me pretty strong language in the report of the commission, and that you used to-day, and it gave me the impression that you thought the contraction works should be practically abandoned. I think it would have been better to have stated the importance of revetment, and at the same time have left that contraction matter alone, because you have to use it in certain places and can not do without it.—A. There is no doubt about that. Major Harrod tells me (a fact that I had lost sight of) that in the estimate that was made there was included the amount of one hundred thousand dollars for each of thirty bars. There were about forty bars, and that estimate was made on the theory that in thirty of those more or less contraction work would be necessary, and we allowed a hundred thousand dollars for each, making three million dollars for contraction works.

Mr. NELSON. Please state to the committee from what cause came the great floods of the Mississippi River, and then please state what levee work has been done by the commission, the effect of that work in repressing and restraining floods, preventing overflows, and also the effect of that levee work upon the navigability of the river. Give a

full history, as far as you can, of the levee work that has been done by the Government, and state as far as you can what work of that kind has been done by State or local authorities, the probable result of a continuance of the work, and the cost of the same.

A. The Lower Mississippi River (by which I mean that part lying below Cairo) receives its water from five great rivers, each having its own watershed and lying in different latitudes and subject to different climatic conditions. The Missouri is fed from a vast watershed lying in the northwestern part of the great valley. The Upper Mississippi comes down from the north, the Ohio from the northeast, and its great tributaries—the Cumberland and the Tennessee—from the southeast. These rivers rise in regions which differ very much from each other in the amount of their rainfall and the time when their ordinary floods occur.

The Tennessee, Cumberland, and Ohio have their head waters in the Appalachian Range of mountains, and come across a great intermediate valley over the whole of which there is a very considerable rainfall. Their floods are likely to occur early in the season, any time, in fact, after the first of January. The floods of the Upper Mississippi and of the Missouri are likely to occur a good bit later in the season. The total amount of water contributed by the Ohio, Cumberland, and Tennessee considerably exceeds that contributed by the other two. I do not know that I can state the exact proportions, but my remembrance is that the discharge of the Ohio at Cairo reaches from 60 to 65 per cent of the whole. The disastrous floods of the lower river usually come mostly, I should say, from the Ohio, with an augmentation from the Arkansas and Red rivers, which also have their head waters in comparatively low latitude. These combinations, however, are somewhat uncertain, and occasionally there is a flood to which all these tributaries contribute in considerable degree. I do not know, however, that any disastrous flood ever occurred without a contributing flood of the first-class from the Ohio. The valley of the river from Cairo down is made up entirely (with the exception of some spurs of Crowley's Ridge which cut across it) of alluvial deposit brought down by these five streams. There was, no doubt, at one time a gulf or arm of the sea extending to Commerce, a point a few miles above Cairo. At the present time, the greatest amount of deposit brought down comes from the Missouri. The Ohio and Upper Mississippi have apparently eroded their channels down to such rocky or gravelly deposits as give substantially clear water.

The Missouri appears to be still in an unstable condition and going on with the process of erosion with great activity. The process of building up the lower valley is one of overflow and deposit. The capacity of the water to carry sediment depends on its velocity. In a state of nature the banks of the river are covered with a dense growth of trees, underbrush, cane, and vines, and, as the overflowing water travels through these obstructions, its velocity is reduced and it drops its sediment. A few miles back from the bank the overflow water becomes comparatively clear. The result is that lands nearest the bank of the river are built up most rapidly, and the surface slopes away from the bank toward the swamps. There is evidence that in the process of this work the river has shifted its channel from place to place in the valley. In a state of nature a great flood no doubt covered the whole alluvial valley which has an area of nearly 30,000 square miles, and traveled down to the sea very slowly. The escape of the water over the bank was therefore in a thin sheet, probably not more than a foot or two in depth at the

bank. The settlement of the country began about a hundred and fifty years ago at New Orleans. It was then a comparatively easy thing to restrain the water for a limited area on the bank by means of a levee. I do not know of any authentic records on the subject, but I fancy that the first levees did not need to be more than 3 or 4 feet high to afford entire protection.

The settlements advanced up the river very slowly, and, as they advanced, the levees were extended upstream, and as the levees were extended they caught more and more of the overflow and brought it within the channel necessarily; and as they thus increased the volume of water passing down within the channel they had to make their levees higher and higher; and that process has continued from that day to this. The levees have been extended upstream, and as they have been extended they have gathered more and more of the discharge into the main channel, and have necessarily been made higher and higher. The commission received its first appropriation, which was only $1,000,000, in 1881, I think. In the following year was the most disastrous flood known in the history of the levees. They were not in a very good condition to receive it. They had suffered great dilapidation during the war, and the people had just fairly gotten under way in the work of their restoration when that flood came and nearly destroyed the entire system. It made an immense number of crevasses and flooded almost the whole alluvial valley.

The plan of the commission originally reported to Congress contemplated the restraint of the floods as one of the means for improving the channel for navigation. It was considered that, as the Mississippi River makes its own channel and must always continue to make it, and as it makes it by the sole agency of scour, it would do that work most effectively by being concentrated in the highest possible degree. The power of the river to scour its channel increases with its velocity, and it was considered to be as necessary for the final improvement of the channel to control the high-water discharge as to control the low-water discharge; and this, it was thought, could be done in no other way than by the extension of the levee system.

According to my remembrance there was no allotment made for the construction of levees from the first appropriation. That was very largely expended in the building of the great plant which was necessary in order to begin the work of channel improvement. The second appropriation was a large one, amounting, I think, to $4,123,000. That reached the hands of the commission for allotment just after the great destruction of the flood of 1882, and, as I remember, a million three hundred thousand dollars of that appropriation was allotted to the repair of levees. In undertaking that work the commission proceeded upon the theory that it was a work which was partly for the benefit of the adjoining land owners, and partly for the benefit of the whole nation, in its contributing effect upon the improvement of the channel. By the early appropriation laws no authority was given to the commission to expend any part of the money in the construction or repair of levees for the purpose of protecting lands from overflow. We were only allowed to make such expenditure in cases where it would, in our judgment, contribute to improvement of the channel. That part of the channel which lay below Red River was not in need of improvement for navigation. That part of the channel which lay above Memphis was in need of improvement, but there were few existing levees there and the riparian communities were not in condition to render any assistance. It was also a disputed question as to whether the restraint

of the floods by levees would effect an improvement in the channel. Upon that subject there was a difference of opinion among the members of the commission. Some members of the commission were of the opinion that the restraint of the floods by levees played such an insignificant part in the improvement of the channel that it was not worth while to expend any money for that purpose at all.

Mr. CATCHINGS. By the channel, Judge, you mean the low-water channel?

A. The low-water channel. But the majority of the commission was always of the other opinion. Through all the changes of its membership it was always the judgment of a majority of its members that the restraint of the floods was essential to a complete improvement of the channel for navigation. It was considered desirable to get some evidence on this point, if possible, and to that end the first object of the commission was to secure a closure of the Yazoo front. There was in that basin a large population, an effective local organization, and the basis of a levee system of considerable extent and value. And there was along that front a considerable amount of bad navigation. It was considered that the complete closure of the Yazoo front would throw some light on the question. From all these reasons taken together, the first effort of the commission was to secure, by cooperation with the local authorities, a complete closure of the Yazoo front. Next after that the commission directed its efforts to complete the closure of the Tensas front. By the words "Tensas front" I mean that part of the bank which flanks the Tensas Basin, extending from Arkansas City to the mouth of the Red River.

In the allotments for levees in both parts of the river the commission uniformly proceeded upon the principle of allotting most to those who helped themselves most. The inducement was constantly held out that wherever the citizens would do the most toward the construction of their own levees the commission would extend its aid first. The response of the citizens to these offers was, as a rule, very heavy and very effective. I have reason to know that they taxed themselves to the utmost limit of endurance. By this sort of cooperation the levees on the Yazoo front and Tensas front were brought to a considerable degree of perfection.

Mr. NELSON. Will you please state in this connection the lengths of the respective levees, and their general size and characteristics?

A. Those two lines are about 300 miles long each. The basins are very remarkable in their geographic conformation. From the fact to which I have alluded that the deposits of the river are most active immediately adjacent to its banks, it follows that the fronts of these great basins are higher than the anterior of them, so that the natural drainage of the areas embraced in them is not into the river laterally, as a man would naturally expect, but down the interior of the basin to its foot. The drainage of the Yazoo Basin is all finally gathered into the Yazoo River, which discharges where the hills come out to the river just above Vicksburg. The Tensas Basin ends at Red River. There is no physical dividing line between the Tensas Basin and the Atchafalaya Basin below it. During the development of the work on these two fronts the Government extended comparatively little aid to the building of levees below Red River.

This was in consequence of the restriction contained in the law, that money should be expended for the construction of levees only where it would contribute to the improvement of the low-water channel for navigation, and as the low-water channel below Red River was not

of improvement, the commission was not able to extend much
he work of the levee building there. A small contribution was
; an early day for the closure of an old crevasse at Bonnet Carre.
ıs done very largely to form a basis of observation as to the
f the closure of a crevasse upon the discharge capacity of the
l below it. There was also some allotment made for the closure
or two old crevasses which were not far below Red River. The
vas that a very heavy burden was cast upon the levees below
ver by the repair and building up of the line above Red River
; any assistance from the Government to the communities below
ver.

ELSON. You mean by that that the construction of the Tensas
zoo levees aggravated the situation below?

es.

ELSON. Necessitating the building of higher and stronger

es. But the appropriations made by Congress were, after a
elieved of that condition, and the commission was empowered
law to regard the protection of lands from overflow as a distinct
lependent object to be attained; and since then the allotments
repair of levees have embraced the country below Red River
with that above. In this way the work has been extended up-
the last basins of which closure has been undertaken being the
of White River and the Arkansas River and a portion of the
ncis front. The work on the St. Francis front was postponed to
, for two reasons. One was that the inhabitants of that basin
ithout any effective organization or means of contributing to
k themselves, and the other was that it was considered that the
of that basin would throw an increased burden upon the levees
and that it ought not to be done until they had reached a devel-
in height and strength which would probably enable them to
he strain.

ELSON. You stated, in speaking of your revetment work, that
t to have been begun above and gone down, did you not?

es.

ELSON. Now, how is it in respect to the levee work? It ought
ı below and go upstream, had it not?

the valley were an unoccupied country and there were no prop-
erests to be considered, I do not know but I would begin the
ıt the upper end, too. But the contrary is the fact. The lower
is densely populated, and the most valuable property and the
population are along the lower part of it. That fact made it
ble, consistently with principles of justice and fair dealing, to
rwise than build the levees from below up. The destructive
f floods in the upper reaches of the river is not increased by hav-
ees below, while the destructive effect below would be greatly
ed by having levees above and none below.

ELSON. Or with insufficient levees below?

ith insufficient levees below.

EST. Well, how about the effect of revetment above?

he effect of revetment above does not injure people below. I do
y that the improvement of the river channel by means of revet-
ınd contraction works would have any sensible effect upon the
l below, either for good or bad.

ears 1894, 1895, and 1896 (the three years preceding 1897) were
uring which there was no flood to speak of—no general overflow.

Everybody familiar with the river knew that it was only a question of time when the flood would come, and the work of levee building during those years was pushed with all the energy which the people and the commission could bestow.

Examined by Mr. VEST:

Q. Do I understand, when you say that the revetment above and the contraction works above would have no effect for good or bad on the lower river, that you mean to say the construction of those works would not raise the level of the river below?—A. Not the revetment and contraction works. No; I do not think so.

Q. You do not think anything would do it but levees?—A. The revetment works affect the channel immediately adjacent to them. They contract the channel way, and so force the water over the bars with a higher velocity, but I do not believe that 20 miles below the works the flow of the river is affected in any perceptible degree by these works.

Q. Is that the opinion of engineers generally?—A. I think so. It is affected for some little distance below. We could see, as a result of the works in Plum Point reach, a visible improvement in the channel, I thought, for a few miles below the reach. I doubt whether it extended more than 20 miles, may be not as far as that. You see, the quantity of water which flows down the channel is the same whether it passes between confined banks or not. The first effect of that confinement is to raise the level of the water a little in the confined portion, and it is that raising of the level by confinement which increases its velocity and gives it an additional scouring power. But that change of level at low water by these works is a very slight one. It is to be measured in inches rather than in feet, and I think its effect must be lost a little way down the river.

Mr. CATCHINGS. You think it would have no effect on the flood level?

A. I should think it would have none at all. The contraction works, where they are entirely successful, do have this effect on the floods. They have a tendency to direct the flood discharge more nearly in the same path in which the low-water discharge flows. That result follows. It frequently happens in a bad reach in the river that the main body of the flood discharge will cut across the bar, taking the shortest line it can find, and go down one part of the channel, and then that the high-water channel will take an entirely different path; and so the main body of the water will flow at flood times in one place and the main part will flow at low water in an entirely different place.

Now, there is no place in the river where the flood discharge and the low-water discharge flow in the same place that you do not have a good channel. And the revetment and contraction works, by introducing a tendency to confine the flood discharge and the low-water discharge to the same path, do have a very valuable effect; and to that extent and in that way only, as I conceive it, the revetment and contraction works affect the flood discharge.

Mr. CATCHINGS. That effect, if any, would be to lower the flood level instead of to increase it?

A. It would have that effect finally; and that effect upon the channel, like the other, would fade out in a few miles. It would not extend down the stream very far.

I was speaking about the condition which the levees had reached at the end of 1896. They were just as good as the commission and the people could possibly make them. They had been built at a standard grade of 3 feet above the highest previously known water.

Mr. NELSON. That was the 1882 level, or 1883?

A. Not necessarily either. The grade of the levees was 3 feet above the highest known water in that locality. And several floods had occurred since 1882, in which the water at particular places had reached a higher stage than in 1882. Although 1882 was, as a whole, the greatest previously known flood, its stage had been exceeded in numerous places on the river, and the standard gauge was 3 feet above the highest known water in that particular locality. Although in a great many cases the levees were not up to that grade, they were as near to it as it was possible to bring them with the means available. That flood was, in a general way, the greatest of record.

Mr. NELSON. You mean the flood of 1897?

A. Yes. Its elevation has been exceeded a little at some places by former floods. It did not quite reach its maximum at Cairo. But taking its elevation and its duration together it did, at Cairo, exceed any former flood, unless it was the flood of 1882. And as to that I am not entirely certain. I do not remember to have made a precise comparison in that particular. The levees it had to encounter first as it came down were the poorest on the river. The levees along the St. Francis front were incomplete—not up to the required grade; and there were numerous breaks in them. The first break, I believe, was at Caruthersville, and there were quite a number on that side. The next breaks occurred at the head of the Yazoo. There is a great concentration of water at the head of the Yazoo basin, due to the inflow of the St. Francis. The St. Francis basin serves as an overflow reservoir. In a state of nature the water begins to flow over the bank immediately after leaving Cairo, and it fills the St. Francis basin at its head and along its side. That basin has an area of about 6,000 square miles. If the flood happens to be a short one, so that the flood wave gets past the lower end of the basin before the basin begins to discharge its accumulation of overflow water, the effect of the basin as a reservoir is to lower the flood below. But if the flood lasts so long that the great, slowly moving body of water coming down the basin encounters the main river at its foot still in flood stage, the result is a tremendous engorgement of water at that point and an increased flood stage and an increased strain on the levees at that point and below. This cause, I suppose, operated in 1897 in a modified degree. The levees on the St. Francis front contributed, no doubt, to check to some extent the inflow into that basin, but the breaks through them and the unleveed portions of the front permitted the ingress of a large volume of water.

Mr. NELSON. Suppose the whole basin had been inclosed by levees at that time, would not the result have been disastrous on the Tensas and Yazoo basins, considering the condition of their levees at that time?

A. I think it would. I think they were not high enough, nor strong enough.

Q. And was it not really an advantage to those two basins that the basin was not entirely inclosed at that time?—A. I can hardly say about that. I have not followed that subject out with the kind of study that would be required to have an opinion about it. My impression has been that the conditions of pressure upon the Yazoo and Tensas basin levees, as a whole, would have been no more serious during the flood of 1897 if the St. Francis Basin had been entirely closed than they were as it was. If the levees had been continuous from Cairo down, the passage of the flood to the Gulf would have been greatly hastened, and a large part of the water which lingered along in the St. Francis Basin

and came out at its foot in time to join the main flood there would have been carried past that point, down the river.

Examined by Mr. NELSON:

Q. And would not the crest of the flood have been much higher opposite the Yazoo and Tensas basins in that case than in the unleveed condition?—A. That is one of the points that I do not feel competent to express a final opinion upon; but my best impression is, not. I believe if I were a landowner in the Yazoo Basin to-day I would rather take my chances with the St. Francis Basin shut up than with it open.

Q. With the levees as they are to-day?—A. Well, with the levees as they are to-day, I think there is pretty certain to be trouble with such a flood as that, whether the St. Francis Basin is open or shut. I do not think that the levees in that part of the river are adequate to hold such a flood, whether the St. Francis be closed or not.

Q. Well, is this not diametrically opposed to the theory that you announced a short time ago about the construction of the levees proceeding from below up?—A. No; I do not think so.

Mr. BERRY. If I understood you correctly a while ago, Judge Taylor, the fact of the long continuance of the flood and the high water remaining until the water in the St. Francis Basin got back into the river again was, immediately below that point, in your opinion, to make it equally as high or higher than it would have been at, say, Helena, if the entire St. Francis Basin had been closed all the while?

A. I do not feel competent to answer that question in just that form. That subject has been carefully studied by men who are more competent to pass upon it than I am. Major Starling and Major Dabney, of the Yazoo country, old engineers and greatly interested in that question, have made some careful studies of it. I have not gone over their work with that degree of care which would justify me in pronouncing an opinion upon it. I can only say this, that the true way to construct levees (the country being occupied and populated) is to go from the lower reaches upward and make the levees as you go adequate for the strain which is to be put upon them.

Mr. NELSON. Will not the strain put upon them be greater, if you in the meantime proceed to dam up basins above?

A. That would depend somewhat upon the character of the flood.

Mr. NELSON. Assuming the flood conditions to be equal?

A. As a general proposition I should say yes. And I should say that the inclination of my mind is to give so much force to that general proposition as to be disposed to continue the general line of policy which has been heretofore pursued, to work from below upward, and not to inclose the upper areas until we feel reasonably sure that the lower areas are adequately protected.

Mr. BERRY. As I understood you a while ago, Judge Taylor, the final closing of all these basins or outlets would not be to endanger the land below to any greater extent than it is endangered in its present condition; or, in other words, if you owned, as you said, land in the Yazoo Basin, you would prefer to have the St. Francis Basin closed rather than open. Is that correct?

A. Yes, I say so. I think that the result of a complete closure of all the basins will be at first to give a considerably higher flood line than would be reached if there were no levees at all. But I think the ultimate result will be to enlarge the channel and lower the flood line And I think the immediate result in ordinary floods is to lessen the strain on the levee by hurrying the flood downstream. The result o the impounding of water in the reservoirs is liable to be an increase

strain upon the levees immediately at the foot of the basin; not so much upon the whole system below. As I said a moment ago, I do not desire to express a final opinion upon the point as to what would have been the effect upon the levees below in 1897 if the St. Francis Basin had been effectually closed. That is a very nice question. There is no doubt in my mind that the discharge of the water out of the St. Francis Basin contributed to aggravate the difficulties at the foot of that basin during the last flood.

Mr. BERRY. And made the water higher at Helena, or just below Helena?

A. I do not know about that.

Mr. NELSON. Do you think, then, that it would be judicious to completely close up the St. Francis Basin with levees before you fortify the levees and improve them above their present condition along the Yazoo and Tensas fronts?

A. No; I do not.

Mr. NELSON. Do you not think, Judge, that before entirely closing up that basin the levees in front of the Tensas Basin and the Yazoo Basin ought to be greatly improved and strengthened and fortified.

A. I think that is the conservative, safe course.

Examined by Mr. CATCHINGS:

Q. Might not the difference between the maximum reached by the flood in 1897 at Helena and the maximum reached by the flood of Helena in 1882 and 1883 be accounted for somewhat by the fact that in 1882 and 1883 the levees were all down in the Yazoo Basin and the Arkansas Basin below, and that the water went over all creation?—A. No doubt.

Q. Whereas if confined the maximum would have been greater at Helena, anyway?—A. There is quite a narrow throat at the head of the Yazoo Basin. The levees on the Yazoo side, for a considerable distance, run pretty near the river, so that there is a narrow waterway right at the point where the engorgement takes place by the discharge from the St. Francis Basin, and it is at that point—not so much along the Yazoo front as a whole nor the Tensas as a whole, but in the region adjacent to the foot of the St. Francis Basin—that the strain comes when that basin discharges its water as a reservoir. And I should think that, as a matter of prudence, those levees ought to be considerably improved and strengthened before the St. Francis is entirely shut up.

Q. Without reference to the St. Francis Basin at all, is it not likely that the maximum at Helena, in 1882 and 1883, would have been greater than it was if the levees of the Yazoo Basin and the Arkansas below there had been as good as they were in 1897?—A. There is no doubt about that.

Q. So that you can not draw a fair illustration as to the effect by making a comparison between 1882 and 1883 and 1897, the conditions being so different there and below?—A. Entirely different; entirely.

Examined by Mr. BERRY:

Q. Do I understand you to assert that if the entire St. Francis Basin was inclosed the rapidity that that would give to the flow of the water would, in your judgment, lessen the danger below rather than increase it?—A. It would have that tendency.

Q. It would have a tendency to lessen the danger if it was all inclosed from Cairo down?—A. It would have that tendency. One of the ways in which I believe the complete inclosure of the river by levees increases

the safety of each part of the alluvial district is by hastening the flow of the water down the river. A large part of the water passes safely before the flood reaches the lower country.

Q. Your judgment would be, then, that it would contribute to navigation as well as to the protection of the land to inclose by sufficient levees the entire river from Cairo to the Gulf?—A. Yes, sir.

Q. You think that is a desirable thing to do?—A. I do not see any reason why you should omit the St. Francis Basin from the system any more than the Yazoo Basin. The St. Francis affects the country immediately below it precisely as the Yazoo does the country immediately below it. In a state of nature, without any levees at all, the discharge from the St. Francis Basin would cross the river, a large part of it, at the foot of the St. Francis and go over into the Yazoo, transfer itself from one side of the river to the other, so that the main flow from the head of the Yazoo in the channel would not include the overflow water from the St. Francis. A large part of that or its equivalent would cross over into the Yazoo Basin and go down the Yazoo Basin; and that did no doubt take place in 1882.

Q. Do you attribute the break at Flower Lake, at the head of the Yazoo Basin, somewhat to the engorgement of the river by the return flow of the St. Francis?—A. I have done so in my mind; yes, sir.

Q. Do you attribute the break at the Biggs crevasse, a little south of Vicksburg, to the return flow from the Yazoo Basin into the river at that point?—A. Yes; I should—in part, at least.

Q. So your judgment is that when the water escapes from those basins and comes back it always must overflow, or is liable to do it?—A. Yes; if it meets a high stage of water in the main river.

Examined by Mr. BERRY:

Q. But all the objections that can be urged to the closing of the St. Francis Basin by the people immediately below there could be urged with the same reason and with the same force by the people below the Yazoo Basin to the closing of that basin?—A. Precisely.

Q. Then you know of no reason why those objections would not apply to the St. Francis as well as to the Yazoo?—A. They apply in the same way.

Q. Is there any justice and equity in saving the people on the Mississippi side by Government funds which would not apply to the people on the St. Francis?—A. Certainly not. In dealing with the question down below, the object was to close the Yazoo front, and at the same time, or as soon thereafter as possible, to close the Tensas front, so that its levees would be able to stand whatever strain might come upon them from the closure of the Yazoo front. The course of the commission in all these matters was necessarily modified my many existing conditions, and among these was the readiness of the people themselves to help build levees. There was a much greater response on the part of the people in the Yazoo Basin than in the Tensas Basin, and there was some complaint from the people on the Tensas side that they were being exposed to danger by the closure of the Yazoo Basin before their levees were in an equally good condition. And without being able now to go into details, I am not sure but that the people in the Tensas Basin suffered some by reason of the closure of the Yazoo Basin before their levees were adequately strengthened.

Examined by Mr. GALLINGER:

Q. I will ask you if there was not, immediately preceding the Mississippi River Commission, a board known as the Low Water Navigation

board; and I will further ask you if you remember anything of the proceedings or recommendations of that board?—A. There was such a board. I would not undertake to state specifically what its proceedings and recommendations were. They took the subject under consideration and made a report, but I have not had occasion to recur to it for many years.

Q. As to the matter of levee construction, let me ask you whether or not, in your opinion, a comprehensive plan of levee improvement is feasible. In other words, do you believe that levees can be constructed from Cairo to the Gulf that will accomplish the desired result of flood prevention?—A. I do.

Q. Am I correct in assuming that at one time the Mississippi River Commission estimated the cost of that great improvement at $18,000,000?—A. I believe so.

Q. Let me ask you when that recommendation was made. Was it prior to the great flood of 1897?—A. Yes; some time before that.

Mr. BERRY. Is it not in your last report?

A. There is a further statement about it in the last report. My remembrance is that there is not a very wide divergence between the last estimate made and the one that I had in my mind preceding.

Q. So far as you know, has the commission modified its opinion since then as to the cost of that great undertaking?—A. Not largely. I have modified mine somewhat.

Q. As I understand it, the estimate was $18,000,000; that that would be the aggregate cost.—A. That is my understanding.

Q. Well, during this inquiry, and especially during the giving of your interesting testimony, this thought has occurred to me: Can you suggest anyway in which the Government and the riparian proprietors can arrange to jointly carry out this great work?—A. I think that can be done. It has been done in the execution of the work so far, until we have come to the St. Francis front, with a considerable degree of fairness. The commission has always had at its disposal a limited amount of money, as compared with the demands of the occasion. The citizens have acted in view of that limitation. In the transaction of the work the commission has devoted to it all the funds it could, and the citizens, I think, as a rule, have raised all that they could. Both sides have done their best so far.

Mr. NELSON. That is in the Tensas and Yazoo?

The WITNESS. Yes. I am not now including the St. Francis.

Mr. CATCHINGS. Is it not a fact, Judge, that the people in the Yazoo Basin, in addition to very heavy taxation, have sold their bonds, amounting to something like two and a half millions?

A. That is true, and also true of Louisiana, except as to the amount of bonds, of which I can not speak.

Q. I understand that by agreement that had been done; but what I was trying to get at was whether there could be any legal or constitutional arrangement made between the two parties in interest?—A. There could be, and I have been of opinion that the time is approaching when there ought be. The thing has taken care of itself so far very nicely by reason of the limitations which I have stated, but I have thought that the time would come when it would be right and proper that there should be some definite basis of contribution arranged between the Government and the citizens.

Q. Are you prepared to venture an opinion as to what the relative obligations of the two parties ought to be, as a matter of percentage?—A. Well, so far the expense, as defrayed, has run along pretty nearly

equally. I believe the total amount expended for levees by the Government up to this time is (I have known exactly, but I do not carry figures very well) something like twelve or thirteen million dollars; and the inhabitants (according to our best information on the subject) have contributed something like two millions more.

Mr. CATCHINGS. That is something like fifteen millions altogether?

A. Yes; and my judgment upon the matter, based upon what they have done and apparently can do, is that an equal division of the burden would not be far out of the way.

Q. On yesterday the president of the St. Francis levee board testified that in carrying out the project of building levees from Cairo to the Gulf the work should commence above and proceed downward to the mouth of the Mississippi. As I understand it, your opinion is that the work should commence below and be carried up?—A. I think that is correct.

Q. And you further entertain the view, I think, that if it is done the other way an irresistible volume of water would be gathered, which would endanger the property and lives of the people in New Orleans and that section? Is that the view you hold?—A. I think so; that is, when the system reached the neighborhood of New Orleans.

Mr. BERRY. You stated, however, that if it was an original proposition, and there was no property to consider below, that your opinion coincided with that of Colonel Driver?

A. It could be done equally well in that way if there were nobody living in the valley.

Mr. BERRY. You think it would have been better in such a case to have constructed them from above instead of below?

A. Yes.

Q. That is, theoretically it would be better to build them from above down, but practically, in view of the property interests involved, the only feasible and proper way is to build them from below up?—A. I think so.

Q. Now, if this grand project of building levees from Cairo to the Gulf were consummated, are you prepared to venture any opinion as to the probable annual cost of keeping the levees in repair?—A. That would be a very vague sort of conjecture.

Q. Would 10 per cent annually of the original cost probably keep them in repair?—A. I doubt whether it would.

Examined by Mr. NELSON:

Q. It has already cost the State and Federal authorities about $28,000,000?—A. Yes.

Q. And $18,000,000 more would be necessary to complete the system?—A. Of course, there is this to be said. In dealing with the probable cost of keeping up the system we have to take into account factors in respect to which we have not adequate experience; at least, I have not. It is not merely a question of repairing embankments against wash or injury by animals or anything of that sort; the principal item of expense is the rebuilding of lines where the river has cut into existing lines and destroyed them by caving, making it necessary to build new ones. The activity of those changes may be affected by the work in a way and to a degree that I do not know how to exactly estimate. When we come to confine the entire discharge between levees, whether it will increase the activity of caving and increase the destruction of levees in that way, or not, I am not able to foretell.

The river will have to have more room for its discharge. Its channel will be enlarged, necessarily. That enlargement will take place to some

extent by vertical scour; I think it will become some deeper; it will also take place in part by lateral erosion and widening. And what it will do in that direction, how much it will widen, how much it will deepen, and what it will do with the material which it takes out of the banks in order to widen itself, and all those things, are questions which I do not believe any engineer can answer now with certainty.

Q. Would it not result in a great saving of money if the contemplated levee system could be undertaken and carried on to completion without interruption?—A. Yes; it would result in a very great saving.

Q. Would you venture to suggest how great that saving might be as compared with the work you have already done in that connection?—A. You could save at least 25 per cent in the cost by that method.

Q. Now, I want to ask you whether or not in your opinion it is practicable at any reasonable cost to build a great reservoir in the St. Francis Basin; and if so, would any material solution of the flood problem result therefrom?—A. I have never gone through those figures except in a very general way, and that was quite a while ago, and I do not retain them in my mind now, but I suppose that the St. Francis Basin could be turned into a reservoir by dividing it up into a number of basins and connecting those basins by gates that could be controlled so as to let the water out when you wanted to, and that enough water could be impounded there to afford considerable relief to the country below in time of flood.

It would involve a great many elements of calculation for which the data hardly exist. Of course it is easy enough to ascertain the area of the country and how much water it would hold at a given depth, and those depths could be controlled by the levees and the dams which you would build across the basin; but a nicer question would be the facility with which you could get the water into the basin in time of flood. In order to make those reservoirs you would necessarily have to inclose a portion of the bank of the river by levees. At the foot of each separate subbasin you would have to have a cross line of levies, reaching from the river to the hills on the west, and if you wanted to store any large quantity of water in it, you would have to extend the levee along the bank of the river from that cross levee to some distance above it, leaving an opening at the upper end of your subbasin for the inflow from the main river. The rapidity of the inflow would depend upon its depth, and, with the river not very much above the bank line, the inflow would not be very rapid, and whether you could coax out of the main channel a sufficient volume of water to effectively relieve the situation below or not, is a question that I am not prepared to answer. You would have some little trouble, I think, in getting the water into the basin rapidly enough to deplete the flood to such an extent that it would not overflow the country below.

You could reduce it a good deal, and possibly you could reduce it to such a point that you would not need any levees below, but I think not. I think the best you could do with that kind of a reservoir would be to so far reduce the height of the flood that the levees below would need to be only of comparatively small extent—make it not necessary to build them so high.

Q. You will observe, Judge, that my question includes the point as to whether or not this can be done at reasonable cost. Are you prepared to make any suggestion on that point? In other words, would it not involve a very large outlay on the part of the Government?

Mr. BERRY. Including compensation to the citizens of St. Francis, Crittenden, Mississippi, Lee and a portion of Phillips County, for their property?

A. Of course the cost would be enormous. In order to get at the relative cost of relief in that way, it would be necessary to make a comparison of the cost of buying the lands, making the reservoirs and maintaining them, plus the cost of maintaining such a levee system below as you would have to maintain, with the cost of protection by an all-levee system like the present. I do not think the reservoir would obviate the necessity of levees below. It would still be necessary to maintain a levee system below; but it would be of less extent and cost.

Mr. NELSON. It is merely a question of degree?

A. It is merely a question of degree, a question of how high the levees would have to be below. There is another question, however, to be considered. The channel of the river depends upon the energy and activity of the water's flow, and nothing is better settled than that the channel deteriorates by diminution of the flow of water. On one side it is to be said that if you could lock up a large volume of water in the St. Francis Basin and hold it there until the floods passed by, and then let it out slowly, so as to pass it down the river at a lower stage, you would have the effect of that controlled flow more continuously than you can get such an effect now, even by levees. On the other hand, you would lack the prodigious energy which the river brings to bear upon its channel in its great floods restrained by levees. To compare those two agencies and say which of the two would in the long run, in a series of fifty years, give you the larger and better channel below is a nice engineering problem. I do not know that anybody is prepared to solve it exactly. So that the effect of your reservoir might be, or it might not be, to ultimately diminish rather than increase the effective discharge capacity of the river below.

Examined by Mr. NELSON:

Q. In connection with the reservoir question, am I safe in assuming that outside of the St. Francis Basin there is no other point on the Lower Mississippi where the construction of a reservoir could be wisely contemplated?—A. There is no place on the lower river where that thing is physically possible, except the St. Francis Basin.

Q. Are you familiar with the conditions in the Ohio River regarding the matter of reservoirs?—A. Somewhat.

Q. Is there any point there where effective reservoirs could be constructed?—A. There is no place there where reservoirs that would control floods are practically possible. They are not physically impossible. You could, by the construction of a very great number of reservoirs scattered about, not only in the foothills of the Alleghanies, but all over the valleys between the Alleghanies and the head of the river at Cairo, impound enough water to control the floods.

Q. And that would involve an enormous outlay?—A. So enormous that it is not to be thought of at all. I do not think anybody would for a minute entertain the proposition.

Q. And is that true of the Tennessee and Cumberland rivers?—A. I included them in my mind as I spoke.

Q. We are also directed to inquire into the question of relieving the flood conditions of the Lower Mississippi River by the so-called outlet system. What is your view as to the feasibility of that scheme?—A. I think it is entirely impracticable, not only upon grounds of theory, but upon the basis of observed facts. I think that the effect of outlets is, in the first place, only transitory; the river must make its own channel, and for that work it has more energy, more effective force, in one volume than it has in a larger number.

If you could divide the river at Red River into two or three separate

ıannels to the sea, you would find that in a very few years the com-ined capacity of all those channels to discharge water would be less ıan the single channel is now. That is the great and fundamental ifficulty in the way. Another difficulty which is practically almost as reat is that there is no place where you can make an outlet that will onduct the water to the sea above Red River. You could do it there.

Q. An outlet there could not very well affect the river much above?—ı. It would do no good at all above except for a very short distance.

Examined by Mr. GALLINGER:

Q. One other practical point that seems to be a matter of contention nd difference of opinion on the part of men who ought to understand t and which has confused my mind, is as to whether or not the bed of he Mississippi River is being lowered or raised; in other words, is the couring process lowering the bed or the deposit of silt heightening t?—A. So far as we have gone, the indications are, and to my mind hey are pretty strong, that the bed of the river is being deepened by he effect of the levees that have been built. That effect is probably very slight. I should expect it to be very slight. The Mississippi River s not like the Yellow River in China and some other rivers in the world, which flow through an alluvial plain and receive at the head of that plain a discharge bringing in great volumes of heavy material.

In those conditions the confinement of the river will tend to fill up the bed at the head of the alluvial plains. If the river receives its water from a rapidly flowing stream which brings down heavy sand and gravel, it must necessarily follow that, upon the diminution of that velocity as it enters the alluvial portion of the stream, it will drop a portion of its load and gradually build up its bottom if it is not allowed to scatter the material over the valley. But we do not have those conditions in the Mississippi River. The amount of sediment brought into the Mississippi River by its tributaries above Cairo is small, except that which comes from the Missouri, and that is very light. It is carried far down the river and is discernible even as far as the mouth of the river at the Gulf. The greater portion of the sediment carried by the Mississippi River consists of material from its own banks which has been washed out at one point by the attack of the river and carried downstream—moved down step by step. That constitutes the greater portion of it.

Q. We are not to have you at New Orleans, and I think the committee ought to have your opinion, as concisely as you may wish to state it, as to the value and results of the jetty system.—A. I think the jetty system was an unqualified success as applied to the mouth of the river; that its value to the commerce of New Orleans and its value to the country at large has been incalculable almost, and abundantly justified the cost of the improvement. But it is now behind the times. The increase in the size of ships has been such as to introduce new problems. Harbors everywhere need increased facilities for the great ships that are now built. And I think the time has come when the interests of the country imperatively demand that the facilities for commerce at the mouth of the Mississippi River shall be increased, and it seems to me that the way to do it is to apply such temporary alleviation as will be necessary to keep the South Pass open until the Southwest Pass can be improved.

Examined by Mr. VEST:

Q. And then close the South Pass?—A. Well, perhaps. It might be worth while to keep the South Pass open for vessels that could use it; but I fancy that with complete improvement of the Southwest

Pass further occasion for the maintenance of the South Pass would cease.

Q. But do you not think that the logical result ought to be the closing of all but the pass which we propose to improve?—A. Do you mean the closing of it to the discharge of water?

Q. We have now three mouths to the Mississippi—the South Pass, Pass a Loutre, and Southwest Pass?—A. Yes.

Q. Now, suppose we come to the conclusion that it is necessary to open the Southwest Pass (they say we can do it for $3,500,000); when we ask the people of New Orleans what we shall then do with the South Pass, they say, "We want both; the South for small vessels and the Southwest for large vessels."—A. I do not think we need them both, though the South Pass might be useful enough to justify its retention.

Q. Now, if we conclude that the Southwest Pass is necessary for those large ships, would you close Pass a Loutre and the South Pass?—A. Do you mean to shut them up so no water could flow out?

Q. Shut them up as far as you could, and put all the water into the channel that it would be proposed to use.—A. The view I take about that is this: When you have enough water for navigation, you are better off than when you have more. The indications appear to be now that the volume of water which flows down the Southwest Pass would be sufficient to keep that channel at its present width and depth. If Southwest Pass will maintain its present channel through the pass and through its mouth with its present flow, my impression is that it would be desirable to not increase that flow. If you should turn the whole discharge of the Mississippi River down the Southwest Pass, you would encounter some difficulties in consequence of the volume of water that you would put there; and one of those difficulties would be the increased deposit of sediment at the mouth across the bar.

Q. Well, you would have that anyhow.—A. But the amount of deposit will be in direct ratio to the amount of water that goes out.

Q. But you want 32 feet, so the New Orleans people say.—A. Yes, you want it, and you want enough water to get that depth; and, when you have enough to get it and keep it, I think you are better off to have no more. All improvements by way of jetties at a river's mouth across a bar necessarily entail the consequence of continual deposit beyond the jetty.

Examined by Mr. NELSON:

Q. The more water, the more silt?—A. The more water passes down, the more silt goes out.

Q. And if you have more water than you need, you get more silt?—A. That is the view I have of it.

Q. That is your theory?—A. That is my theory; that when you have as much water as you need for the maintenance of the channel and the scouring out of the bar it is better to have no more.

Mr. CATCHINGS. Your idea is that you would not close these other passes unless it should seem to be necessary?

A. No. Do whatever the situation seems to call for when you get to it.

Examined by Mr. VEST:

Q. When you state that these levees ought to be built from Cairo to the mouth (costing $18,000,000), do you make that statement in connection with the revetment system and the dredging? What would be the effect of that as an isolated improvement? Suppose, for instance, you were to levee and not revet. Of course you would use your dredge

boats anyway; but suppose you do not revet at all, what would be the effect of the levee system?—A. If you complete your levee system so as to confine your flood discharge to the channel you get a more effective agency in the work of scour. The river at its flood makes a bigger path for itself than it would if it were not restrained. A considerable deposit of sediment in the river is avoided, and the channel keeps larger and keeps open better. At the same time, if you make no revetments, if you leave the scouring force of the river to spend itself on the banks, you will have bars; and you will have to remove those bars by your dredging apparatus at low water; you will have a continued wandering around of the river, and there will be considerable descruction of levees, and a great deal of mischief in consequence of the caving of banks; all that you can prevent only by revetments. And if you make up your mind that the cost of those is too great to warrant their construction, you have simply to stand the consequences.

Q. Well, to make the improvement complete (and that is the point I want to get at), we ought to have revetment, dredging, and levees?—A. Yes, to make the work ideally complete you ought to have all those.

Mr. CATCHINGS. And contraction works where needed?

A. And contraction works where needed. That would be the ideally perfect river. Such a river as that would be the engineer's dream.

Q. That would cost about a hundred millions, all combined?—A. The estimate of the commission was that it would cost sixty millions to Vicksburg; one hundred and twenty millions, I think, to Red River—forty years to complete the work to Vicksburg with all available material, and, I suppose, as much more to extend it to Red River.

Examined by Mr. NELSON:

Q. And $18,000,000 for levees would make one hundred and forty millions?—A. Yes.

Q. And then about three millions more for these dredge boats?—A. Something like that; it will depend on the lenghth of time embraced in the calculation.

Q. So it would make about a hundred and fifty to a hundred and sixty millions?—A. The scheme, as now in course of execution by the commission, is within comparatively small limits of cost. The completion of the levee system upon the estimates which have been made, especially if it is accomplished by the cooperation of the United States and the States, is not a heavy burden; and the maintenance of the system, if it were thus divided, would not be a heavy burden; and the operations of dredging can be carried on at relatively quite a small expense. And if the people and the Government are content to go on with that form of improvement, the burden will not be at all serious. It will leave the country below subject to the inconveniences of this lawless, wandering, mischief-making stream, and whether they are willing to stand that or would prefer to embark in a system of its complete improvement, with their eyes open to the cost, is a thing which the people and Congress must settle.

Examined by Mr. CATCHINGS.

Q. Let me ask you a question as to the effect of levees, if they were made complete, upon interstate and foreign commerce, without reference to that commerce which travels the Mississippi River. In other words, the Mississippi Valley on both sides is traversed now by railroads, and is crossed by railroads longitudinally and latitudinally; those roads are engaged in interstate and foreign commerce; nearly all the grain which was exported from New Orleans last year (forty-two

million bushels) went over those roads, down the Mississippi Valley. Now, suppose we have no levees and this whole country were subject to perpetual inundation; could those railroads which are engaged in interstate and foreign commerce afford to maintain themselves?—A. I should doubt it.

Q. So, in building levees we not only protect, as you think, commerce by the river and the riparian owners along the river, but you give free vent to this whole valley for the purpose of interstate and foreign commerce through the agency of railroads?—A. Yes, sir.

Q. Is it not true that during the flood of 1897, traffic on nearly all of these railroads was seriously interrupted, in some cases for weeks at a time?—A. Traffic was very much interrupted.

Q. I will say that Mr. Fish, president of the Illinois Central Railroad, told me that the branch of his road which runs from Memphis to New Orleans was damaged physically to the extent of half a million dollars by the flood, to say nothing of the fact that he was not able to operate the line for nearly two months. So the Government might properly take that into consideration in considering the effect of levees, might it not?—A. Certainly. I would like to recur for a moment to a question that some time was spent upon, as to the effect of allowing the basins to remain open as reservoirs. I think the effect of the discharge of a great basin like the St. Francis into the river during the progress of a great flood is a very serious and disastrous one. Its effect is confined mainly to levees which are not very far below that point. That effect gradually dies out as you go down the river. And I think, on general principles, that the levees below the foot of each basin ought to be built to a grade as high as we can make them, or as high as we believe they need to be, if we can do that, before we proceed with the closure of the basin above.

Mr. NELSON. That is the way I look at it.

WITNESS. But upon the whole, when the work is done, and taking the safety of the levees——

Q. You mean when it is done along the whole line?—A. Yes. Taking the safety of the system and of the people into account, I think they would be better off with all the basins closed than with some of them left open.

Examined by Mr. BERRY:

Q. As a rule, it would be better to close them than to leave it as it is now?—A. I think so. If I were an inhabitant of the Yazoo Basin, my wish about it would be to first make the levees in my own front secure, and then shut up the front above.

Q. In point of fact, did the closing of the Yazoo Basin raise the water at Vicksburg or along the Tensas front in any way whatever? Is there any real evidence that it made it higher at Vicksburg or in the Tensas Basin than it was before?—A. That question is complicated by two considerations. I think that the closure of the Yazoo and the Tensas combined made a higher stage of water at Vicksburg than if they had been both open, probably; but I think that the people of the Tensas were greatly benefited by the closure of the Yazoo. I think they were a great deal better off with the Yazoo front closed than they would have been with the Yazoo front open, and subjected to the great engorgement that took place at the mouth of the Yazoo. I have always felt that way.

Q. You have always felt that the engorgement there injured the people of the Tensas rather than benefited them?—A. The engorgement of water at the foot of the Yazoo injured the people in the Tensas more

han the increased height which results from the completion of the evees on the Tensas and the Yazoo. They are better off now than hey were before.

Q. Would not the same conditions apply to the closing of the St. Francis as apply to the closing of the Yazoo?—A. Exactly the same, provided you make the levees on the Yazoo high enough to stand the strain during the transition.

Examined by Mr. CATCHINGS:

Q. Do you think it likely that during the flood of 1897, if the levees on the Yazoo Basin had not broken, the crevasse would have occurred at Biggs?—A. It is pretty hard to answer such a question. It is very hard to tell what would have occurred if something else had been different. I do not think that the levees of the river, as a whole, were high enough and strong enough to have contained that flood.

Q. You will notice I limited the question to the break at that place, that being the point where the return flow of the Yazoo came in.—A. I have no doubt it contributed. To say whether the break would have occurred or not if the breaks in the Yazoo levees had not occurred involves other considerations.

Q. Yes, but I was simply speaking of that particular place in order to identify it in your mind, if I could, with the return flow from the Yazoo Basin.—A. That that return flow aggravated the situation there is no doubt in my mind at all.

Q. You think that the return flow from the St. Francis, coming at a time when the main river was still high, contributed to the damage below there?—A. I think it probable that it did, but that involves some other factors. The situation at the foot of the St. Francis is not exactly like the situation at the foot of the Yazoo in this: That the body of the flood was poured in at Cairo; that is where the great and sudden elevation took place, and if you had had that entire volume of water confined within levees, the effect would have been to raise the water quickly to a considerable height along the whole front of the St. Francis Basin and at its foot as well.

By the time you get down to the foot of the Yazoo the immediate effect of the whole flood wears off somewhat. As you go down the flood does not rise so fast; the water does not rise as fast at the foot of the Yazoo as it does at the head of it. The whole great trough of the channel has to be filled with water as the flood goes down the river, and that diminishes the rapidity of the rise. So the conditions at the foot of the St. Francis are not exactly the same as they are at the foot of the Yazoo, and I am not prepared to say but that, if the whole St. Francis Basin had been leveed during the flood of 1897, the flood wave would have been transmitted down the front of the St. Francis so rapidly that it would have reached that point with an elevation as high, possibly, as it had in fact. I am not quite competent to figure that out. You have to take a great many things into consideration in order to come to a conclusion upon that point.

Q. And on that you desire to express no opinion?—A. As to what would have been the result in a supposed case at a particular place I do not wish to express an opinion.

Q. As to whether it would have been higher or lower?—A. As to whether it would have been higher or lower.

Q. Is it not a fact that the trade between the people who inhabit this valley, and the other parts of the country, is very enormous in the aggregate?—A. It is very great indeed. This is a great productive valley.

Q. And the traffic between the people who dwell in the valley and those in other parts of the country (New England and everywhere) is enormous?—A. Yes.

Q. Now, is it or is it not a fact that the destructive influences of such floods as that of 1897 seriously embarrass that traffic, not only as to the agencies by which it is carried on, but as to the actual volume of it? Do not such floods diminish the power of the people in the valley to make purchases and their power to meet their obligations? In other words, is not the effect of such a flood as that of 1897 felt all over this country?—A. It has that effect, of course.

Mr. GALLINGER. You mean more particularly traffic by rail, do you?

Mr. CATCHINGS. I had begun by asking the Judge if the amount of business transacted by the people of this valley with the people in the other States was not very enormous in the aggregate, and he said it was. I then asked him if the effect of such floods as that of 1897 was not to embarrass the trade, not only by preventing people from paying their debts, but diminishing their purchasing power.

Mr. GALLINGER. There is no question about that. The question of the interruption of railway traffic impressed me very much.

The WITNESS. I think that a levee system which will inspire confidence is indispensable to the development of that country. Its greatest value, to my mind, is not in the immediate saving which it makes in damages from overflow so much as in the building up of confidence on the part of the people. The effect upon that confidence of the growth of the levee system in the last ten years has been very remarkable. As the levees have extended upstream and people have been saved from annual overflows and have begun to feel confidence in the security of the protection, there has been a prodigious development of life and business in the valley. I do not think it is extravagant to say that the value of the property in the Yazoo and Tensas basins has increased 50 per cent and may be a hundred in the last ten years.

Examined by Mr. CATCHINGS:

Q. That is, taking the basin as a whole, you mean?—A. Yes.

Q. You do not mean an individual plantation?—A. No; the whole of it. The value of land has been greatly increased and the amount of business has been greatly increased by the confidence which has taken possession of the community in the security of their protection.

Q. Based upon the expectancy that the Government is going to see them through?—A. That has been the foundation of it very largely. You never can have an adequate development of the wealth and resources of this country down here until you inspire in the minds of the people a perfect confidence that they are going to be protected against floods.

Examined by Mr. BERRY:

Q. If I understand you correctly, when, in speaking of the levees, you said they should be made absolutely safe before you think it wise to close the St. Francis Basin, you referred to levees at the head of the Yazoo; you did not include all the levees down to the mouth of the river?—A. No. I was thinking particularly of the levees that would have to sustain the greatest strain, those along the Yazoo front, and especially those at the head of that basin. The Tensas levees at their head are subject to a strain of another character. They have to take the inflow of the Arkansas. But I had in mind in my answer particularly levees on the Yazoo.

Mr. NELSON. I think I have seen in some reports lately that from

the experience of the flood of 1897 it is conceded it is necessary to raise the height of the Yazoo levees, on an average, from 2 to 3 feet to make them safe?

A. I think so.

Q. The whole length?—A. Yes.

Q. Now, if the commission had ample funds, if you had all the money you needed, how long would it take you to complete the entire levee system and make it as you contemplate it?—A. A very few years. It would diminish the economy of the work somewhat to undertake to do it too quickly. The resources of the country for the doing of that kind of work are not infinite, you know, and if you throw too much of it in the market you increase the price of it.

Q. You could not very well do it to advantage in less than three or four years, could you?—A. I think not.

Q. It would be divided over three or four years?—A. I should think so.

Q. Now, was not that estimate of $18,000,000 based on a higher price per cubic yard than you can have it done for now?—A. It is an estimate which is being exceeded now in some parts of the country, and which could be reduced somewhat.

Q. That is what I mean. Could it not be reduced?—A. It could be reduced somewhat by the use of certain and continuing appropriations. As things now stand, the levee work is costing a great deal more than it ought to. One year's appropriation is only available for that season.

Q. If you had a four years' continuing contract could you not do it to greater advantage?—A. To much better advantage.

Q. And cheaper than you have been doing it?—A. Cheaper than we are doing it now?

Q. Yes.—A. Yes, sir.

Q. How much does it cost now?—A. It runs all the way from 12 to 16, 18, or 20 cents per yard. We have an appropriation of so much money for levees. We get at it along in the late summer, and, in order to make it available for the floods of the next year, we must require the levee contractor to have his work done by the 1st of March. It gets into the fall months before we can go through the necessary formalities in regard to advertising, letting a contract, etc., and the contractor is then put under bonds to have his work done by the 1st of March, and that takes him into the rainy season, when he loses a great deal of time by rain, and when the earth may be wet and costs much more to handle than if it were dry. Now, if we could let that contract in the spring and give the contractor until the 1st of March, so that he could utilize the summer and fall months, we could get it done for not much over half of what we have to pay if we crowd it into a few months in the winter.

Q. You could probably get it done for sixteen million, four million a year for four years, couldn't you?—A. I should think we ought.

Examined by Mr. CATCHINGS:

Q. Under the appropriation made in the river and harbor bill of 1892 you were authorized to contract ahead?—A. Yes.

Q. So that you could have work done to be paid for as Congress might thereafter appropriate?—A. Yes.

Q. Now, we thought in Congress that we had done the same thing in the year 1896; we thought we had again placed the Mississippi River under a continuous contract system, but it was ruled in the office of the Chief of Engineers that that was not true, and therefore you can only contract for a given year. Now, I wish to ask you if, as a result of that,

the price of levee building has not greatly increased?—A. Very much indeed.

Q. In other words, when you had the power to contract ahead you got your levee work done much cheaper than you can now?—A. It is costing us now, I think, at least 25 per cent more, on the whole, than under the provisions of the former act.

Q. And is it not advisable that the law be amended so as to place it, beyond question, as it was before 1892?—A. I think so. It would save a great deal of money.

Q. Can you give any idea as to the proportion of lands in the Mississippi Valley which are now cultivated, and the proportion which remain yet to be subdued?—A. It is pretty hard to form an opinion about that. I have talked with a good many citizens about it, and on the basis of such information as I could get I have made some calculations in that respect. My best opinion is (and it is very largely conjectural) that a good deal less than half of the land which would be tillable is now occupied and cleared.

Q. So that, if we had a system which would guarantee protection, at least one-half of the valley which is now idle and a waste could be used, and no doubt would be, for tillable soil?—A. I think so.

Q. Is not the effect of such a flood as that of 1897 to derange the whole postal service of the Government in this valley?—A. Necessarily.

Q. So that when the Government undertakes to serve the people with mail it has to do it as best it can at a greatly increased cost?—A. Yes; during the flood of 1897 I had occasion to send a telegram to some place where there was no telegraph station. The operator took his book and looked up what he thought was the nearest telegraph station to the post-office and sent a dispatch there. It turned out that between those two places there was an impassable flood, and there was no communication for a number of weeks between the one place and the other, and my dispatch reached its destination about a month after the time I sent it, although the operator did his best to get it there. He sent it to the place which appeared on the map to be the nearest post-office.

Q. So the postal service of the United States suffers greatly during times of flood?—A. It is entirely cut off in some places.

Q. And it is conducted under much greater expense?—A. Yes, sir.

Examined by Mr. NELSON:

Q. Please state the method in which the work of levee construction and repair is carried on by the State and Federal authorities, respectively, and the manner in which they cooperate in the work.—A. The usual method is something like this. The commission determines what proportion of a given appropriation shall be devoted to the work of repair and extension of levees. It then subdivides that gross amount and distributes it among the various levee districts on the river. There is a levee district in the St. Francis Basin; the Yazoo Basin is divided into two levee districts (an upper and a lower), and there is an upper Tensas district and one or two other districts in the Tensas Basin, and there is an Atchafalaya district and a Ponchartrain district, and so on. A certain gross amount of money is allotted to each one of those districts——

Q. By the commission? A. By the commission, and approved by the Chief of Engineers and the Secretary of War. The expenditure of the money is then left in charge of the district officer, who is charged with executing the work in that district. It was the custom

or some time for these various officers to meet together as a board and make some more detailed disposition of the funds, but of late years that has been discontinued. The commission has itself directed the distribution of the funds more closely than it did formerly. At the present time the officer in charge of the district, upon consultation with the engineers who have charge of the levees on behalf of the State, determines where he will expend the money. That is done with reference to the importance of the work and the respective convenience of the army officer and the State engineer. We have been very fortunate so far, I think, in having very judicious men on both sides to do this work. There has been substantially no friction or trouble between the engineers of the United States and the State authorities. The gentlemen who have represented the State authorities have been, without exception, as far as I know, men of unusual ability and prudence, and they have gotten along with our engineers without a particle of difficulty that I know of. The work having thus been divided among them, the engineers on the part of the United States execute the portion which they have assumed, and the officers representing the local districts execute the rest of it.

Q. Ultimately, then, the two authorities assume the construction of separate portions of the levee in the respective districts?—A. Yes; it is done in that way entirely. Each authority lets its own contracts for certain specified work.

Q. After the levee is constructed, who has charge of it?—A. They continue a sort of joint charge. The engineers of the United States look particularly after the work they have done, and the State authorities look particularly after the work they have done.

Q. Is there not a system of patrol during flood periods?—A. There is a system of patrol at those times. I do not know that I can state accurately in regard to it. Some other gentlemen can describe it to you better than I can. My understanding of the matter is that they accommodate themselves to circumstances; that where the State authorities consider it necessary to extend their supervision over the entire line, they do it, and the United States officers do the same; that where there is an insufficient force on either side to do the work well, the other side supplies the deficiency if it can. There never has been any specific or distinct division of authority on that subject between the United States engineers and the State officers. They have gotten along very nicely so far, simply by the exercise of mutual good judgment and hearty cooperation.

Q. In your opinion, after the levee system has been completed and the question is simply a question of maintenance and care, under what authority ought that supervision and care to be exercised?—A. I should suppose it would be desirable to have the responsibility lodged in one source of authority or the other, and I do not know that it is fundamentally important which it is. It could be well done by either authority. There is a little to be said in favor of the supervision of those works by the United States, to the effect that the authority of the United States is somewhat more impressive, and I think commands a little more deference among the people than the authority of the State officers. The United States Government is recognized as a more tremendous source of authority than the State government. Its officers in charge are army officers, and their authority is the authority of an army officer; while the State officials are made up from the citizens of the place, and their neighbors, I think, are not quite as much afraid of them as they are of representatives of the United States Government.

Q. And their powers are more apt to be hampered by local pressure?—A. A little bit; yes.

Q. Federal officers could exercise more independence?—A. I think so; a little bit. On the other hand, there is this to be said, that if you should always have as competent and faithful men as we have had, Federal officers might lack that incessant interest in the work which the self-interest of the local authorities would inspire in them. As I said, we have been so fortunate as to have a very excellent class of Federal officers down here—men of a very high sense of duty and men who, I think, are disposed to be quite as watchful as the local authorities. But you might not always have that class of men.

Q. Might it not be well to leave to the State authorities the matter of merely patrolling the levees and watching over them, and leave the matter of supervision of repairs to the Federal Government, or could the two coexist in that way?—A. I do not think there would be insuperable difficulty in any direction about it. I think the mere matter of patrol could be lodged in the hands of the State authorities. I should think, if the United States is going to assume the responsibility of keeping the levees in repair, it would be better that the whole duty of patrolling them should also be lodged in the hands of the Federal officers. One of the serious difficulties to be contended with is the disposition of people to use the levee as a highway. It is many times convenient to use it for that purpose, and by using it in that way they wear it down. The people have also a habit of cutting openings in the levee in order to get across it with wagons and teams, for access to the bank of the river, and then leaving the openings unclosed. And they have had, until recently (and I do not known but they may do it to some extent still), down at the lower end of the river where they want to get water to their rice fields and things of that kind, the custom of putting pipes through the levee. That has been prevented to a large extent lately by legislation in Louisiana. A great many bad breaks have come from things of that kind. Injurious use of levees could be more effectually prevented by the authorities of the United States than by local authority.

Upon the subject of the probable cost of maintenance, referred to in an earlier part of my examination, I ought to say that I do not know what it would be. The cost of merely maintaining a levee after it has been well built is an insignificant amount. To keep it up against deterioration from the action of the elements, if it be protected against injurious use by men, would require a very small fraction of 1 per cent of the original cost; it would be an amount so small as to be trifling. The cost of maintenance that is to be considered is the cost of replacing levees which have been destroyed by the caving in of banks adjacent to them, and the building of new lines in anticipation of such caving. That will always amount to something, and, in the history of the levee system, has amounted in the past to a very large sum. What it will be will depend in a great degree upon the care with which the levee lines are originally located. There were reasons why the people in years gone by were in the habit of locating their levees dangerously near to the river. One of those reasons is the fact that the highest land is there, and that that is the place where the levees can be built most cheaply. Another, and probably a more prevailing reason, has been that the land owners along the river are very reluctant to have their lands thrown outside the levee by new construction. And as the levees have been located by their fellow-citizens and neighbors with whom they have more or less influence, they have in many cases, and I should

ıy perhaps as a rule, induced the location of levees upon lands which ere too near to caving banks for permanent safety.

Another circumstance which has no doubt contributed greatly to the ıme result is that the resources of the people for protection by levees ıve been limited, and the engineers have been compelled to consider ıe question of immediate protection, rather than permanent protec-on, and so when a levee was threatened by caving, to build a new one ıat would answer for a few years, and thus keep up the line continu-ısly, rather than build the new levee on a location further back, where would cost more money. That has been one of the elements of the tuation which engineers have had to contend with, and which they ɔuld not get rid of. The United States Government in the work done nder the commission has pursued a much more conservative course in ıat respect than the State engineers had been in the habit of pursuing efore. The rule which has been laid down, and I think generally bserved, has been to locate no levee at a point where it would be ndangered by caving within twenty years, as nearly as the progress of ıving could be foreseen. The cost of maintenance will depend largely pon the observance of some such principle of permanence as that. I hink that a study of the history of the lines and of the breaches by aving would disclose an approximate law upon which an estimate ɔuld be made of the probable cost of maintenance. I have never made hat study myself. I think that the material in the archives of the ommission and accessible from the records of the levee engineers along he river would enable a reasonably reliable calculation to be made of 'hat the cost of maintenance would be. There are some gentlemen resent who, I think, ought to know more about it than I do. I have tated the principles upon which the question is to be answered. My nswer must be that I do not know.

U. S. S. MISSISSIPPI,
Memphis, Tenn., February 4, 1898.

A. S. CALDWELL testified as follows:

I want to say, as the representative of the Cotton Exchange, that e regret exceedingly that your time is so limited, because I know that ıything I may say to you upon the subject immediately under consid-ation will not be nearly as effective as the hospitality the city of emphis might show you. But, if you can not accept our hospitality, shall have something to say, although I am quite convinced you have ard it a hundred times. I will say it, at any rate, in order to fulfill y duty to my constituents, who would believe I would not do my duty I did not say something to you.

I do not know that I thoroughly understand the purposes of this ɔmmittee, or the scope of your inquiries. I think, however, I do.

Mr. NELSON. We are here to investigate the matter of the floods or erflows of the Mississippi River and what can be done to restrain ıem, and also whether any help can be obtained by means of reser-ɔirs or by the outlet system; and, further, we are going to investigate ıe outlets at the Passes and look into the matter of securing a better ıannel to the sea. But in this immediate section of the country our ading point of inquiry is the matter of the floods which you have ıd, and the best method of preventing damage from them in the ture. On that subject, particularly, we would be glad to hear any ggestions you may make.

Mr. CALDWELL. I thank you, Senator. I particularly wished an expression from you on this subject, because, when our committee met this morning, there seemed to be some difference of opinion as to the scope of the committee that we are now addressing.

As to the various methods of preventing floods in the future, I am not here to speak. Those matters can better be told you by those who are thoroughly familiar with that subject. I can only speak to you of general conditions, and very briefly, of what we, as business men, feel to be the only preventative in this immediate section of the country. We feel that there is but one way in which these floods can be prevented, and that is by the building of levees. If it were possible to assist in the prevention of floods by outlets, that would be discovered by competent engineers, and, if it is a means, we are not opposed to it. If there is any way by which these floods can be prevented through the medium of reservoirs, we are not against that. We occupy the same position that any other good citizens of the country would—anything to prevent them. But in Memphis, we are in favor of the levee system. It has been, we think, successful to a very large extent. We think it can be made permanently successful. I, for one (and I believe I voice the sentiments of pretty nearly every intelligent business man of the city of Memphis), believe that this time of absolute protection against floods will come quicker and surer by national control of the levees. At present our levees are built by funds derived by taxation, by our different levee boards, assisted by the Government of the United States. There is no continuity of design. The levees are built here and there, and there is a great deal of waste—there must be, because the matter is not taken hold of in a systematic manner. We believe if the United States Government would take hold of this whole levee system—and I am not speaking of any particular levee district, but the whole levee system—that the work would go forward more rapidly and at a great deal less cost than at present. And we are willing to bear taxation for it, too. We are not asking the National Government to take hold of this for the purpose of relieving us from taxation. We are willing to burden ourselves, as we have in the past, to the very fullest limit of possibility.

I thought possibly the matter of taxation for levee purposes was a subject that you may not have known accurately; that you may have had it in statements of percentages, etc. And one of the strongest arguments (and possibly the only one that I can bring to you individually) is to show you some of my own tax receipts. Here is a tax receipt covering a plantation in the Fifth Louisiana levee district—which you will visit as you go down the river. The amount of taxes I paid on that plantation was $474.68. That is made up of an ad valorem tax on the land, an acreage tax, as we call it—5 cents an acre—and a general State levee tax, which goes into a general fund (which the engineers can explain to you). It is also made up of a cotton tax of $1 per bale. I sold that plantation last year for $9,000, and was very glad to do it. Now, there is a tax of 5 per cent upon the value of that property that we have been imposing upon ourselves cheerfully, and will continue to pay if there is any hope that our occupation of the land will not be temporary.

Mr. CATCHINGS. That receipt does not include your State and parish taxes?

The WITNESS. No; what I have given you is the tax for levee purposes only.

Here is a receipt for the payment of a special levee tax. Here is a

ax of 5 cents an acre, and here is a district levee tax, which goes to he State, and then there is a cotton tax. That is in the Fifth Louisiana evee district.

Here is a receipt for the tax on a plantation that I now own in General Catchings's district, in Washington County. The amount of ax I paid on that plantation this year was $558.07, purely for levees. That does not include our other taxation, but that went into a general und for the repair and building of levees. Now, that plantation I ave frequently offered for sale at about $18,000, and have not been able to sell it.

Here is a receipt upon some land I own in the Arkansas district just across from here, the St. Francis levee district. Their tax is a uniform tax of 2 per cent upon a valuation which is not quite the value of the property.

I present these to you in specific form, because I shall then ask you if it is within the possibilities of the people in this district to do more than they are doing. If it is not possible for them to do any more, is it wise for the great Government of the United States to let this whole territory here (the extent of which you doubtless have before you in accurate form) to go to waste? And even with our levee system as it is now, and with the few breaks we had last year, the flood was so general that it simply means that if we are to consider that a possibility of every year of high water, our lands will have practically no value and sooner or later must be abandoned. Some persons, more brave than others, may stick out a little longer, but eventually the result is inevitable that if we can not protect it from the waters of the Mississippi River the country must be abandoned.

Now, is it worth while for the United States Government to do it? Will it come within the general powers of the Government to protect this country or to assist in protecting it—to take charge of it with all its great force and power along with the local taxation—which we are quite willing to continue if thought advisable? Is it worth while to protect this great portion of the United States, or shall we let it go, as eventually it must unless we get Government aid in some form; and Government aid in its old form, while we have been very thankful for it, and while it has assisted materially, has not been what the case demands? Now, this territory, in its great extent, provides labor and a living for a large population, very many of whom are without means except from their own labor. To depopulate this country or to allow it to go backward, it seems to me, would be a very serious detriment to the public in general. If the country is prosperous, if it is built up and protected, it is difficult to tell where the ramifications of business would go to, how far the general benefit from a prosperous country here would reach. It seems to me it goes beyond any immediate benefit to be derived by the land owners who are protected by the levees built; that there is a vast benefit to the country at large.

I am deliberately not speaking of the subject of the benefit to navigation; I am speaking solely in regard to the matter of the floods, the way to remedy them, and the proposition of the Government taking charge to prevent them in the future.

I think this is a subject that is thoroughly worthy the consideration of the United States Government, even if it should incidentally result in the use of public funds for private purposes. I am quite well aware that that great political problem is involved, and that it is a stumbling block to many people, but I think that if this committee will look at it in a broad view, look at it as a committee that is willing to depart

radically from old principles and old ideas to arrive at the truth arrive at the general good, that that difficulty will sink into insig cance.

R. C. GRAVES testified as follows:

Mr. Chairman and gentlemen of the committee, speaking for Merchants' Exchange, I want to say that we are in line with the Co Exchange on this question of levees. We have already learned w we think the whole country is now learning pretty fast, that if territory is reclaimed and subdued, it must be with the aid of the Un States Government working with the various levee boards in the var States. There is no question but what the great river has overs the capacity of the people along its banks to deal with it, and I bel that public opinion is fast coming to the idea that it is only by Gov ment aid that this can be done, and that we will do our share as l we may. As evidence of that, I am told that in the St. Francis le country they have this year paid 97 per cent of their taxes. All taxes will be collected. People are paying their taxes cheerfu Formerly they collected only 30 or 31 per cent each year, but now people want to come in and pay all they are asked to pay, to do t proper part. I do not believe the levee boards would ever accomp it unless the people not only put in their money, but ask the Gov ment how they should expend it, to a certain extent. One levee dist might have an idea that levees should be built at a certain point, the Government, looking at it from a higher standpoint, might say levee should go further back; and the Government should be the to say that private interests should set back and do the proper thi

I have studied this river some. Of course the engineering part get from the engineers. But I have mixed with the people a good in the various conventions. I was at Davenport last fall, at Vicksb two or three years ago, and at Greenville, and in my judgment people in the valley have come to the conclusion that it is by le and not otherwise that they are to get protection. Of course, details of having an outlet at the lower end of the river is an engin ing proposition, and no one in Memphis will object to using any m ods of that sort. It might be that you can not treat the river all al Doctors do not give the same medicine for all diseases. If the riv conditions require an outlet down there, I am satisfied the engin will find it out and make it. We want to work with the Governm and do what they want us to do, and do it intelligently, or else accomplish nothing. It is really a question of reclaiming this country down here, or not reclaiming it, it seems to me. It seem me it is worth reclaiming.

With the levees we have in the St. Francis district now, we hav increase of 70 per cent in the population already, and they beli in the levees and are paying taxes as stated, and only want a conti tion of what has been done. The people believe in this, and I h you gentlemen believe in this, and whatever you see in going along river will confirm your ideas that it is the proper thing to do. have some of the St. Francis Levee Board people with us, who mi say something to you in regard to the reason that Memphis had hig water than ever before. We had a big river the whole length, but, recollect, we had a little more here than we expected to get with gauge marks at other points, and some little complaint has been m as to the leveeing of the St. Francis district giving trouble to Memp I do not look for any serious trouble at Memphis from this levee w any more than temporary, and it is a well-understood idea that pri

interests must suffer a little temporarily for the public good, and I believe that as these levees are completed the shore between here and Cairo will be thoroughly protected and better than it has been.

I only want to say for the Merchants' Exchange that we are for the levees, and for the Government supervision of this river, with the idea that the people living along its banks will pay a tax cheerfully to the limit of their capacity.

I do not think it is worth while to detain you longer, any more than to say that we want to work together and to ultimately reclaim the land along the river. It is worth reclaiming.

Mr. Chairman, we have a report which we would like to file with you.

The report was marked "Exhibit V," and is as follows:

EXHIBIT V.

OFFICE OF ST. FRANCIS LEVEE BOARD,
February 3, 1898.

Col. R. C. GRAVES,
Chairman of Cotton and Merchants' Exchange Committee.

SIR: In response to your request on behalf of your committee for information relative to the St. Francis levee district, I take pleasure in submitting the following:

The St. Francis levee district was created under an act of the general assembly of the State of Arkansas, which became a law on the 15th day of February, 1893, and is composed of all the counties of Crittenden and Mississippi and all that part of the counties of Craighead, Poinsett, Cross, St. Francis, and Lee that are subject to overflow by the Mississippi River, and also of a small part of Phillips County.

In the same year and at about the same time the St. Francis levee district, in Missouri, was also organized, and includes the counties of New Madrid, Pemiscot, and Dunklin. The Missouri district, while intimately connected with ours by a common interest, has no official connection with ours. The two districts extend from Point Pleasant, Mo., to the mouth of the St. Francis River, in Arkansas.

REVENUE OF DISTRICT.

At the first meeting of the board of directors of the St. Francis levee district (Arkansas) it was decided to submit to the landowners of the district a proposition to levy an annual tax of 4 cents per acre on all the taxable lands of the district. This proposition was voted on at meetings of the owners in the respective counties and received more than two-thirds of all the votes cast.

At first there was considerable opposition to the payment of the tax, but gradually opposition died out, and our annual collections have increased every year, until in 1897 we collected nearly 90 per cent of all the taxes levied, and in two counties—Mississippi and Lee—practically all of the taxes of 1897 were collected. Our revenue from taxation is about $60,000 per annum, which is supplemented by the sale of lands that were donated to us by the State. Our total revenue since the 1st day of May last approximates the sum of $100,000. I wish in this connection to state that when I speak of revenue of the district I refer to that of the Arkansas district alone. I have not at hand reports from the Missouri district.

LEVEE CONSTRUCTED.

From the last annual report of the late Capt. H. N. Pharr, our chief engineer, we learn that the total levee construction to date had been as follows (to May 1, 1897):

	Cubic yards.	Cost.
Missouri levee district had built	1,045,865	$127,300.83
Arkansas levee district had built	1,275,932	240,041.31
Total by two districts	2,321,797	367,342.14
The United States built in Missouri	839,678	79,945.67
The United States built in Arkansas	919,837	154,091.01
Total United States work	1,759,515	234,036.67
Total levee built in Missouri	1,885,543	207,246.50
Total levee built in Arkansas	2,195,769	394,132.32
Total	4,081,312	601,378.82

The United States Government has now under construction and about completed closing of breaks and repair work in Missouri, estimated to cost $11,000; and closing of breaks, repair work, and new levees across Craighead Point, Arkansas, estimated to cost $56,000.

The St. Francis levee district of Arkansas has now under construction and near completion 8 miles of repair work, from Luxora to a point below Osceola, which is estimated to cost $16,000; topping off of 9 miles of levee between Nodena and Pecan Point, which is estimated to cost $5,500. We also have under construction 17 miles of new levee in prolongation of our continuous line from Pecan Point south, estimated to cost $75,000, showing a total of enlargement, closing of breaks, topping off, and new work at the present time (exclusive of Government work) of 34½ miles, and estimated to cost $102,500. I submit this statement to show you gentlemen that not for one moment have we been content to lie down and wait for the General Government to come to our aid. Aid we must have, but in the meantime the people of the St. Francis levee district are leaving nothing undone that they have the power to do to complete the levees in their district.

EFFECT OF LEVEES.

Since the levees have been built in New Madrid and Pemiscot counties the population has increased more than 75 per cent, and in Mississippi County, Ark., nearly 100 per cent. Land values have greatly increased, and many thousands of acres of land that were but a few years ago considered valueless are now being opened up and put in a state of cultivation.

AREA OF THE TWO DISTRICTS.

There are about 1,000,000 acres in the Missouri district and about 2,000,000 acres in the Arkansas district. Before the organization of our district not more than 10 per cent of the lands in our district were in cultivation, but now the percentage of acres in cultivation is increasing rapidly.

Finally, we ask of you not merely your indorsement of the levee system, but your hearty and enthusiastic cooperation in the work of reclaiming the lands in the St. Francis Basin. We feel that we have contributed much to the greatness of Memphis, and though we have done much, as we think, it is but a tithe of what we will do with our lands protected from inundation by the Mississippi.

Very respectfully, yours,

HUGH R. MCVEIGH,
Secretary St. Francis Levee Board.

MEMPHIS, TENN., *February 4, 1898.*

SAMUEL C. EMERY, sworn, testified as follows:

Examined by Mr. NELSON:

Q. What is your full name?—A. Samuel C. Emery.

Q. What is your business?—A. Weather Bureau observer.

Q. How long have you been in that work?—A. Twenty-five years.

Q. Where have you been stationed?—A. At La Crosse, Dubuque, Cairo, and Memphis.

Q. How long have you been stationed at Memphis?—A. Two years.

Q. You were here during the flood of 1897?—A. I was.

Q. And took observations?—A. Yes, sir.

Q. Is the statement in this book (which I show you) your report?—A. Yes, sir.

Q. Is that statement and that table true and correct?—A. It is to the best of my belief.

Q. And that is your statement of testimony?—A. Yes, sir.

The statement referred to in the book is paragraph 111, on pages 74 and 75, United States Department of Agriculture, Weather Bureau Bulletin E, Floods of the Mississippi River, and is as follows:

111. Effect of the St. Francis Levee.—Before comparisons can be made between the present flood and those which have occurred in former years it is necessary to take

ito account the changed conditions which have resulted from the construction of ıe Arkansas levees. Since 1890 there has been built a line of levee along the west ank of the Mississippi River, extending from Point Pleasant, Mo., south to Pecan oint, a distance of 125 miles. The purpose of the levee is to protect the St. Fran- is bottom, the greater portion of which was formerly subject to an annual overflow. f this bottom much is not under cultivation, considerable areas being covered by succession of swamps and lakes having a heavy growth of gum, sycamore, and ypress trees. In former years the bottom had been flooded more or less whenever he Mississippi at Cairo reached a 41 or 42 foot stage. The water after leaving the ain river passed into the St. Francis Basin, through which runs the Little and St. 'rancis rivers. Through these channels it again found its way to the Mississippi at ı point about 12 miles north of Helena, Ark. The effect of leveeing the west bank f the Mississippi in front of the St. Francis bottom is to compel the water to pass lown the Mississippi from Cairo to Helena.

In the following table a comparison is made of several earlier floods with that of this year. The floods occurring from 1882 to 1886 reached about the same stage at Cairo as the flood of this year. The maximum stages at Cairo, Fulton, Memphis, and Helena during the floods of 1882–1886, together with their mean, and the corresponding stages of this year's flood, are presented:

Year.	Cairo, Ill.	Fulton, Mo.		Memphis, Tenn.		Helena, Ark.	
	Maximum stage.	Maximum stage.	Below stage at Cairo.	Maximum stage.	Below stage at Cairo.	Maximum stage.	Below stage at Cairo.
1882	51.8	36.7	15.1	35.0	16.8	47.2	4.6
1883	52.2	36.3	15.9	34.8	17.4	46.9	5.3
1884	51.8	35.7	16.1	34.2	17.6	47.0	4.8
1886	51.0	35.4	15.6	34.8	16.2	48.1	2.9
Mean	51.7	36.0	15.7	34.7	17.0	47.3	4.4
1897	51.6	37.4	14.2	37.1	14.5	51.5	0.1

The average difference in stage, in the earlier floods, between Cairo and Fulton was 15.7 feet; between Cairo and Memphis, 17 feet; and between Cairo and Helena, 4.4 feet. The building of the levee has caused a decrease in the difference between those points; that is, it has raised the stage at Memphis about 2.5 feet above what it would have been, had the water been left to flow over the lowlands of Arkansas. So, instead of a difference of 17 feet between the Cairo and Memphis stages, we now have about 14.5 feet, and, had it not been for the breaking of the levee, it is probable that this difference would have been lessened at least an additional foot. In other words, the levees, if kept intact, would result in some 3 feet more water at Memphis than under former conditions. At Helena the change is still more marked, and the former difference of 4 feet has entirely disappeared, and, had it not been for the great crevasse at Flower Lake, the Helena flood crest would probably have been considerably above that at Cairo.

U. S. S. MISSISSIPPI,
Near Greenville, Miss., February 4, 1898.

WILLIAM STARLING, sworn, testified as follows:

Examined by Mr. NELSON.

Q. Major Starling, what position do you occupy?—A. I am chief engineer of the lower Yazoo levee district.

Q. Under State authority?—A. Yes.

Q. Under the authority of the State of Mississippi? From what point to what point does your district extend on the river?—A. From the boundary line between Bolivar and Coahoma counties to the mouth of the Yazoo, or at least as far as that levee district extends toward the mouth of the Yazoo.

Q. How long have you been engaged in that position?—A. I have held my present position for about fourteen years. I have been in the levee service for about sixteen years.

Q. Will you state to the committee in your own way the sources of the flood of 1897 and of the previous great floods with which you are familiar or have looked up? Perhaps you might give us a brief statement of the floods of 1882 and 1883; they were the largest, were they not?—A. And 1884 also.

Q. Give us first a brief statement as to the sources of those floods, and then come down to the flood of 1897.—A. The floods of 1882, 1883, and 1884 were very similar. The three floods came in great part from the Ohio River. They culminated at Cairo in the latter part of February, and they reached the same height within a few inches. The flood of 1882, I think, was about 51.9 at Cairo; the flood of 1883, 52.2; that of 1884, 51.8; there was only that difference between them; they were at almost the same stage. And they all culminated from the 23d to the 27th of February. Almost all proceeded in great part from the Ohio. An estimate that I made, I think for the flood of 1882, was that 69 or 70 per cent came from the Ohio; in 1883 about the same; and in 1884, about 85 per cent.

Q. And those floods were superinduced by what?—A. By rainfall in the Ohio Valley principally. The 1884 flood was also supplemented by quite a heavy snowfall in the Upper Ohio Valley, in the Allegheny country. But generally the reason was excessive and heavy rainfall. Those floods were the greatest of which we have any record in the Mississippi Valley. It has occasionally happened that considerable floods come from the Missouri and Upper Mississippi, but there are very few of those; 1858 was a case in point, and 1844, and, in a less degree, 1892. In 1892 I think about 55 per cent came from the Upper Mississippi and Missouri.

Q. What was the average duration of those floods—the danger stage?—A. Speaking offhand (I have not any data with me), I suppose it might be, at Cairo, two months, perhaps. Farther down—at Vicksburg, for instance—it was considerably longer.

Q. In those cases?—A. Yes. That is, that it was above what they call the danger line.

Q. Unless you wish to say something more about those floods, come down to the flood of 1897.—A. The flood of 1897, in great part, came from the Ohio River and its tributaries. Accurate information on that point can be had from the records. I do not suppose it is worth while to recapitulate them—I do not know that I could without memoranda—but my impression is that something like 75 per cent of that flood came from the Ohio.

Q. At what period did it occur—later or earlier than the previous floods?—A. Later. The first break in my district occurred on the 28th of March. It was a later flood than those of 1882, 1883, and 1884.

Q. What was the character of the flood, as to its duration, compared with those earlier floods?—A. My recollection is it was of nearly the same duration. I think it stayed at Cairo somewhat longer than the previous floods; it had rather a greater duration at Cairo.

Q. Was that flood and the earlier floods aggravated either in volume or in duration by water coming from the Mississippi above Cairo?—A. Not very much. The rise from the Mississippi above Cairo came after the crest of the flood of 1897 was past; it had, therefore, very little effect. It did not affect at all the height of the flood. It prolonged it, but had no effect upon the height.

Q. How in 1897?—A. I speak of 1897.

Q. It had no effect——A. In 1882, 1883, and 1884 it had very little effect.

Q. In 1897 its chief effect was in prolonging the flood?—A. In pro-
nging it.

Q. Did the other streams below—the St. Francis, the White, the
rkansas, and the Red rivers—have anything to do with aggravating
e floods?—A. Yes; they have almost always had a very considerable
fect. The flood stages of the White, Arkansas, and St. Francis have
en frequently decisive. It has made a great flood out of what per-
ps would not otherwise have been a great flood.

Q. And that has occurred, has it not, because the rainfall in those
asins has been simultaneous with the rainfall in the Ohio Basin?—A.
recisely. The rainfalls come from the same storm. The same storm
hat falls on the Ozark Mountains continues up the Ohio Valley and
alls on the slopes of the Alleghenies.

Q. I wish you would go into the matter of the source of these storms
nd what brings about the freshets.—A. The great floods of the Mis-
issippi Valley, so far as my observation extends, have been caused by
hose cyclonic rainstorms that have their origin in the Gulf of Mexico,
r have their greatest development in the neighborhood of the Gulf.
They originate generally in southern Texas, then proceed up the Ohio
Valley, distributing their rainfall as they go, and pass out at the mouth
f the St. Lawrence River, skirting the western slope of the Alleghany
Mountains.

Q. That is what produces the excessive precipitation?—A. In almost
ll the instances that have come to my knowledge that has been the
mmediate cause of the great floods of the Mississippi Valley. First
hey generally fall, as I say, on the slopes of the Ozark Mountains, and
ave frequently been attended by very heavy precipitation. In 1890,
or instance, in four months there was 40 inches of rain fell in the Ozark
egion. It is a region of excessive rainfall. They then continue up the
Ohio Valley and distribute their rainfall there. The very same storms
hat occur in the southern regions also occur in the northern regions.
t is the same storm that gives the precipitation throughout the whole
entral valley, in the majority of cases.

Q. Now, will you please go on (in asking you this question I am fol-
wing your mode of discussing it in your pamphlet) and state to the
ommittee the effect of the new levees upon the flood heights in 1897—
e effect of the construction of the latest and newest levees?—A.
fter the war the levees on the Arkansas side of the river, in the Ten-
s Basin, were neglected for many years. The levee system was not
ept up. The country was impoverished from continual successive
verflows, and almost nothing was done toward the preservation of the
vees, after the close of the war, until about 1887. On the Mississippi
de the local authorities had kept up a levee system in the particular
strict that I represent—that is, from the line between Coahoma and
olivar counties down. The levees of the upper part of the Yazoo
asin were without repairs and in a ruinous condition until about 1884,
en it, too, organized and formed a levee system of its own.

Q. That was under State authority?—A. Under State authority. In
82 the Mississippi River Commission entered into cooperation with
e State organizations, and since that time the levee system has been
rried on under a coordination of the two authorities. The State
thorities, however, on my side of the river have done much the larger
rtion of the work.

Q. Please state in this connection the order of time in which these
stems were built and completed.—A. There was a levee system
ganized in Mississippi in 1858. That was suspended by the war.

After the war the Mississippi levee district was separated into two districts, an upper and a lower district. The upper district soon got into difficulties and went into bankruptcy, as it were, till it was reorganized in 1884, but the Lower Yazoo district maintained its organization from 1865 to the present time; it maintained a complete levee system, and has done so from that day to this. We have expended from 1865 up to the present time nearly nine millions of dollars.

Q. In the Yazoo district?—A. Yes; in the Lower Yazoo district, the one which I represent.

Q. Nine million dollars, under State authority?—A. Nearly nine million dollars; more accurately, eight and three-quarter millions, under State authority. From 1882 up to the present time (since the Government went into partnership with us) the State authorities have expended about five millions and a quarter, and the United States Government have expended about two million one hundred thousand dollars, so the local authorities have really borne much the heavier share of the burden.

Q. You have expended, then, nearly fourteen million dollars?—A. No; nine million dollars on the part of the State authorities represents the amount up to date from 1865; but since 1882 we have expended about five and a quarter millions.

Q. Of those nine millions?—A. Of those nine millions. The State and local authorities have expended something less than $11,000,000 since 1865.

Q. During that period, then, the Federal authorities—you said the State; you meant the levee district?—A. I meant the levee district—the local authorities. Yes.

Q. When I refer to State, I mean outside the Federal authorities. I include State and local when I say "State."—A. Yes.

Q. State and local have expended nine million as against two million by the Federal Government?—A. Yes.

Q. Now as to the upper district.—A. Of that I can not give you accurate information. I am not well informed on that subject. My colleague, Major Dabney, who will meet you at Vicksburg, will tell you about that.

Q. How about the Tensas Basin?—A. Of that I know nothing.

Q. Now tell us as to the relative time of the construction of these levees as they were prior to the flood of 1897.—A. I do not know that I quite understand you.

Q. I would like to know, for instance, when the levee on the Tensas Basin was built.—A. The levees on the Tensas Basin were begun in earnest about 1886 or 1887.

Q. And when was it completed?—A. In 1887. That is to say, there was a continuous line of levee then from the upper end of the Tensas Basin down to the lower end. That was the first year. The flood of 1888 was the first flood that was entirely kept out by the Tensas system of levees, if I mistake not.

Q. Has it been added to and fortified since?—A. Continually. It is a never ending work, and that is going on up to this day.

Q. What is the average height of that levee?—A. I can not say. On the Mississippi side the average height of the levees is about 13 feet. I mean in my own district.

Q. When did you first complete your system as it was before the last flood?—A. Our system has been complete—that is, it has been continuous—since about 1865. That is to say, there was then a small line. It was an imperfect line, but it was nevertheless a continuous line.

Q. But what was the condition of it prior to the flood of 1882?—A. It

inuous along the whole front of the district, but much lower in
ıd of inferior dimensions. In 1858, according to Humphreys
ɔot, the levees of the Yazoo Basin were about 4 feet high.
ıg to the report of the levee commission of 1874, in the latter
levees of the Lower Yazoo district were 8 feet in height. This
stake, however, for in 1882 an accurate survey was made, and
age height was found to be only about 7 feet. The slopes were
little as 2 feet base to 1 of height and the crown was often as
4 feet. Now the slopes are never less than 3 to 1, and are often
d the crown, or top width, is never less than 8 feet. The aver-
ht is about 13 feet.
irteen feet is the average height?—A. That is about the average
t present.
that about the average height of the upper basin, too?—A. I
now. I can not give you accurate information about that. My
on is that the levees there are not quite so high as ours. They
the Arkansas and White rivers to contend with, and their
think, are 2 or 3 feet lower than ours.
hat information can you give us about what are known as the
tiver Basin levees?—A. I can not give you much. I can not
anything authentic. What I could tell you would be merely
d hand.
ıean the reach of levees extending from the St. Francis Basin
the head of the Tensas Basin?—A. As I say, what information
give you as to that would be simply at second hand. I can
you any authentic data.
w proceed to this branch of the question—the effect of the
tion of the new levees upon the flood height of 1897 clear from
ce up to Cairo. Give us your views in full on that subject.—
ɜ is no question at all in my mind that the reclamation of each
ve tract of land has had the effect of raising the high water
ıat is a matter of fact. It has done so. It was maintained at
, by some of our sanguine levee people, among others by the
Eads, that the confinement of the waters would not result in
ng of the water line, because it was contended that the river
ld scour out to keep pace with it. That, however, has not
experience.
at is not true, according to your experience?—A. Well, it is
ot true. The facts show the contrary. The high-water line
ı in proportion as the water has been confined. There has been
able scouring of the river, but it has mostly turned its atten-
he banks, rather than to the bed. It has resulted in caving,
ıan in scouring, so far as our experience goes.
d the chief result has been the raising of the water level in the
A. Unquestionably.
each successive basin was inclosed, you had to build higher
-A. Undoubtedly. Since 1882 our levees have been raised
feet. In 1882 the average height of the levees of the district
present was about 7 feet; now it is about 13.
ll, were they then deemed sufficient, as a rule?—A. No; they
sufficient. They broke all to pieces in 1882. The water ran
t over them from one end of the valley to the other.
w high were they then, do you say?—A. About 7 feet.
d now they are 13?—A. Now they are about 13. Senator, I
ish to be misunderstood about this. I am simply speaking of
ıg of the water line. I am not speaking with reference to the

raising of the bed of the river or anything of that kind, for that has not occurred. I am merely speaking of the water line.

Q. Yes; I understand you. Now, from 1882 up to the flood of 1897, according to your experience, what has been the rise of the level of the river in high water?—A. As I say, our levees have been raised about 6 feet since that time.

Q. What would have been a sufficient height to have protected you in 1882?—A. Very nearly the same as would have been sufficient during the flood of 1897, about 4 feet—from 3½ to 4 feet higher than at present.

Q. What was the difference, if any, between the character of the flood in front of your reach of the river in 1897 as compared with 1882, 1883, and 1884?—A. In my opinion, very little. In my opinion the two floods were of very much the same dignity.

Mr. BERRY. One about as high as the other?

The WITNESS. It would have been if it had all been confined. The difference was that in 1882 the levees were all down and the river ran broadcast over the whole bottoms; but if the river had been confined there would have been very little difference between the height of the two floods, in my opinion.

Q. There was about the same volume of water?—A. About the same volume passed the latitude, you might say, of Arkansas City.

Q. But I mean what was the difference in the height of the water?—A. The water was very much higher in 1897.

Q. How much higher was it in 1897, opposite your levee?—A. I will give you the record at Greenville, Miss. In 1882 it got to 41.7; last year it got to 46.7. There was just about five feet difference.

Q. Five feet difference between the floods of 1883 and 1884, and 1897?—A. Yes. The floods of 1882, 1883, and 1884, were almost the same.

Q. About 5 feet higher in 1897?—A. Yes; than in 1882.

Mr. CATCHINGS. You confine that statement as to 5 feet only to Greenville?

A. Only to Greenville. At Vicksburg the difference was only about 3½ feet.

Q. Suppose you give the two extremes, the lower and the higher, and the fluctuation between the two.—A. At Arkansas City, in 1882, it got to 47.2 on the gauge; this last year (1897) it got to 51.9. At Greenville, in 1882, the gauge reached 41.7; in 1897, 46.7. At Vicksburg, in 1882, the gauge reached 48.8; in 1897, 52.5.

Q. It ran, then, as I gather from your statement, from 3 to 5 feet higher in 1897 than in 1882?—A. Than in 1882.

Q. Or any of the previous floods?—A. Yes.

Mr. BERRY. How do you arrive at the fact that the volume of water was about the same in 1897 as in 1883?

A. It was measured in both years. That is to say, the discharge of the river was taken at several important points, and from all the evidence that we could gather together, I think it was about as I have stated. I do not think there was very much difference. In 1882 very careful discharge measurements were made at five or six different points on the river, and by combining the evidence, in fact by computing it as carefully as we know how, I do not think there was very much difference between the two; there may have been a little.

Q. I see from a statement that I have before me that in 1882 the maximum at Helena was 47.2.—A. Yes.

Q. And I see that in 1886 it was 48.1.—A. Yes. In the meantime the ees in the Upper Yazoo district had been built. That is what caused e difference.

Q. So that the confinement by those levees raised the gauge?—A. ıdoubtedly. The flood of 1886 was a much less flood than that of 82.

Examined by Mr. BERRY.

Q. How do you take these discharge measurements?—A. The river is unded, in the first place, across from bank to bank; soundings are ken to ascertain the shape of the cross section of the river, the shape of ı bed as it were. The velocity measurements are taken with current eters, at very frequent intervals, to get the swiftness of the current. 'ell, if you know how fast the river runs, the velocity of the current, and ɔu also know the contents of the cross section of the river; then mul- ply the one by the other and you have the discharge of the river—the ımber of cubic feet per second. In other words, suppose the river ıs an area across of 200,000 square feet and its velocity is 6 feet per ɔond, then you have a discharge of 1,200,000 cubic feet per second. hat is the whole thing. And measurements were taken in 1882, all ırough the year. They were taken with very considerable precision, ıd you can get a very fair idea of the discharge from the records of at year.

Q. Now, you have stated that the volume of water passing at Green- lle, for instance, in 1897, was substantially the same as in the prior ɔods of 1883, 1884, etc.?—A. Yes.

Q. That being the case, how do you account for the fact that the ıter was 5 feet higher at Greenville in 1897 than at those previous ɔods?—A. Because in 1882, and the other typical floods of that kind, ılf the volume of the river, almost, went over the banks; whereas, in 97 it was confined, until a comparatively late stage of the flood, tween levees, 88 per cent or thereabouts of the water being retained.

Q. It was owing, then, to the fact that the water was confined tween levees above, wasn't it?—A. Unquestionably. I think there n be no rational doubt of it.

Mr. CATCHINGS. When these crevasses occurred, and water began to n into the Yazoo basin and the Arkansas, how much was the fall at 'eenville?

A. Two feet immediately, and then it remained there for a considera- e time.

Q. From your observation and experience, in connection with what ɔu have stated, what is your opinion as to whether the bed of the river ıs been rising during the interval between those earlier floods and this st one? You have spoken of the rise in the surface of the river. ow, the question is, has that simply been a rise of the water, or has ıe bed of the river been filling up in any part?—A. In my opinion ıe best way to get at the situation of the river bed is by low-water ɔservations. Of course at low water the surface of the water approxi- ates more closely to the bottom of the river. Well, for a good many ars past, in fact ever since the completion of the levee system, each ccessive low water has been, you might say, lower than the one before The lowest water that we have ever had has been of recent years. think it was in 1895, if I do not mistake. And there has been almost continual dropping of the low-water line since the completion of the vee system up to this time.

Q. You think, then, if I understand your statement, that there has

been, if anything, a lowering of the bed of the stream?—A. That is my decided opinion, and there is no evidence whatever of any rise in the bed of the stream.

Q. While this rise of 5 feet in the height of the river has occurred, during that same interval there has been a lowering of the bed of the river to some extent?—A. The evidence all points that way, so far as I know it.

Q. Now, you know something about the construction of the levees in front of the St. Francis Basin?—A. Very little. I have no personal acquaintance with it.

Q. No; but you know of them as a matter of history and fact?—A. Yes.

Q. In your opinion as an engineer, did the construction of those levees, the work that was done there, the partial inclosing by those levees, have any effect upon the flood of 1897, in prolonging it, aggravating it, or raising the height of the water?—A. Along the front of the St. Francis Basin the building of the St. Francis levees unquestionably had the effect to raise the high-water line. Below the St. Francis, below Helena, my opinion is that the building of the St. Francis levees had very little to do with it. The building of the St. Francis levees, together with the closure of the White River front, raised the high-water line at Helena very much.

Q. The two combined?—A. Yes. I think the leveeing of the White River front had as much to do as the leveeing of the St. Francis front, because there used to be a waste weir or discharge, as it were, below Helena, that drew off the water below there and caused it to assume a less height than it otherwise would have done. Below the mouth of White River I do not think that either one of them had any very considerable effect on the river. Down at Greenville I would not care whether the St. Francis and White River fronts were leveed or not, except for the greater danger of coincidence of floods from the lower and the upper rivers.

Q. Would not the complete closure of all the basins above you up to Cairo necessitate an increase in the height of your levees?—A. It would probably render some increase advisable.

Q. To what extent, on an average?—A. That is difficult to say. Perhaps a foot or two in the upper part of our district and less in the lower part. I can not say, though. I would not like to give an authoritative expression on that. The only opinion I could give would be an offhand opinion, and probably would not be entitled to very much weight.

Examined by Mr. BERRY:

Q. Did the closing of the Yazoo Basin tend to raise the water opposite the Yazoo Basin?—A. A good deal.

Q. Did the closing of the Yazoo Basin affect it down below the mouth of the Yazoo?—A. I doubt whether it did, Senator; below Vicksburg, we will say. I do not think it matters much to the people below Vicksburg whether the Yazoo Basin is closed or open.

Q. You think that the closing of the Yazoo Basin tended to raise the water along there?—A. Locally, along its front, but not below the Yazoo Basin. I think the river at Vicksburg would have got to about the same height whether the Yazoo Basin was open or closed.

Q. Would not the same thing apply to the St. Francis Basin. I have said so. Below the St. Francis Basin I do not think it would amount to much. The only reason, Senator, that I think the closure of that basin might have an important effect on us would be that the

ds from the upper river from Cairo up, for instance, would reach mouth of the White River about the same time as the floods from Ozark Mountains—the floods from the Arkansas and White rivers. t really, in my opinion, is the menace to the lower river from the ure of the St. Francis and White River fronts. As it is, the ds from Cairo are prolonged. They are delayed something like or eleven days in the St. Francis Basin. But if that basin should losed, the floods from Cairo would reach the mouth of the Arkansas about the same time that the floods from Fort Smith and Jackson- t would. That really is the danger.

. The point I wanted to make was that the closing of the Yazoo in tended as much to throw the excessive water on the Arkansas as the closing of the other would to throw it on the Mississippi ?—A. Undoubtedly. There is no difference between the cases.

Examined by Mr. CATCHINGS:

. Do you think, Major, that the closing of the White River front a greater effect in raising the water on you than the closure of the Francis front?—A. In our locality? Yes; I think so.

. Than the closing of the St. Francis Basin?—A. Yes; that is my ion.

. At the time that the flood reached its maximum at Helena, had return flow begun from the St. Francis?—A. My impression is that ad. But the return flow from the St. Francis was very much com- ated in 1897 by the number of breaks that took place there, etc. ve not studied that question very carefully, and I would not like nswer you without more mature reflection. My impression is that id.

. I had the impression that when the return flow came in there was orge made and the river was impounded there?—A. The break at wer Lake occurred about that time. The whole thing is very com- ated. I really could not say without more careful reflection.

Mr. BERRY. Was there not a second rise which came down from ro after the first rise? Was there not a second rise that came down ut the time that the water came down the St. Francis Basin, at the th of the St. Francis River?—A. My impression is, yes.

. And the two came out there about the same time at Helena?— That is my recollection.

. That fact would have a tendency to raise the gauge at Helena, ld it not?—A. Undoubtedly.

. Do you remember the date of the Flower Lake crevasse?— April 4, I think.

Mr. NELSON. At what stages of the water does the river do the most ring of its bed? At extreme high stages, at medium stages, or at stages?

. The river scours its bed in different places at different times. At water it scours on the bars and builds in the pools. At high water oes just the reverse, builds on the bars and scours in the pools. lly the river, taking it all through the year, is almost stable, it just sfers material from place to place according to stage.

Examined by Mr. CATCHINGS:

. Colonel Gillespie has looked at his memorandum book and states t the maximum at Helena was April 4, and that that was the day he Flower Lake crevasse.—A. That is my recollection. It would e gone still higher if it had not been for the Flower Lake crevasse. ink that is what I stated. That is what I intended to state.

Q. In that connection I would like to ask you, as an engineer and a man of large experience on the river, whether it is your opinion that the return flow from the St. Francis River contributed to make that break at Flower Lake?—A. I think not. I think the effect would have been just about the same. Well, of course, the return flow contributed to it at that time. But if the St. Francis Basin had been leveed, in my opinion there would have been about the same height attained that there was at Helena, anyhow. In other words, I do not think that the non-leveeing of the St. Francis Basin would affect the gauge height materially at Helena.

Q. You think the maximum would have been about the same whether it had been leveed or unleveed?—A. Yes; provided the levees of the White River front had been built up.

Examined by Mr. BERRY:

Q. If it was leveed, would there not be a greater volume confined and the flood likely not last so long below the St. Francis as if it was not leveed?—A. It probably would not have lasted so long. The difficulty then would be that the floods from Cairo and the White and Arkansas rivers would reach the mouth of the Arkansas about the same time. But, as you say, it would pass off sooner.

Mr. NELSON. In other words, it might be more severe and higher, but it would be of shorter duration?

The WITNESS. Yes.

Q. What effect does the construction of levees have upon the navigability of the river?—A. That is a very complicated subject. I have not examined it carefully, and I would not care to give an offhand opinion about it. So far as I can say, navigation has apparently been improved since the work of improvement on the river began. Whether that is attributable to levees, to contraction works that have been built, etc., or not, I have not carefully examined and would not like to say; it is a little out of my province. My decided impression, though, is that navigation on the river, in that part of it which is entirely confined between levees, is decidedly better under the improved conditions than it was previously.

Examined by Mr. NELSON:

Q. Well, it is evident, both from what you state and from what others have stated, that the levees all the way up from Vicksburg, on both sides of the river, will have to be strengthened, fortified, and enlarged. Is that not a fact?—A. Of that I conceive there can be no doubt.

Q. They will have to be built higher?—A. Much higher.

Q. On an average at least 2 feet?—A. More than that.

Q. Three feet?—A. Four feet.

Q. In order to complete the levee system, that is, if you inclose all the basins above, make a complete closure of the St. Francis River basin, you will need upward of 4 feet more levee?—A. Upward of that, Senator, because that allows you no margin. It would have to be 4 feet higher to just barely hold the water, and of course you need a margin of a couple of feet or so over that. In my opinion, the levees should be 6 feet higher than they are at present.

Q. And that is needed before you could close up the river above with safety, is it not?—A. In my opinion.

Examined by Mr. BERRY:

Q. Well, do you mean to say that they are high enough if the basins are not inclosed, or would it not require additional work if there was no other closing? Are your levees perfectly safe if they are not closed

ow, or ought they not to be higher whether the basin is closed or hether it is not?—A. As I say, I do not consider that the closure of ie St. Francis basin cuts any very material figure with us. So far as am concerned I do not care much whether the basin be closed or not, cept for the local effect in the vicinity of the closure.

Q. Then, as I understand you, if the levees generally along were all creased from 5 to 6 feet, from Cairo down, you think they would hold ie water from any flood that we have had in the past?—A. That is my pinion.

Q. That they would absolutely hold it, unless there was an accident?—A. That is my opinion; unless we have a greater flood than e have had up to this time. Of course we can not tell what the future ill be, but I am judging from past experience.

By Mr. NELSON:

Q. Your whole front then would need a 6-feet higher levee?—A. In ay opinion.

Q. And would that be the case on the other side, the Tensas and White rivers?—A. Yes.

Q. And all the way up?—A. Yes.

Q. And also the upper Yazoo district?—A. Yes, about that.

Q. Now, in building levees that way, taking into account that the ountry is settled, occupied, and improved as it is below, is it not the afer and more judicious course to proceed from the lower river upward han from the upper river downward in the construction of levees?—A. That is a very serious question. I should suppose it would be safer to do as you state.

Q. What is the average cost of building your levees, per yard, in your district?—A. The cost has been very variable indeed, beyond all imagination. It has extended everywhere from 7 cents a yard up to 30. So I can not say off hand. I suppose it might be, maybe, 20 cents a yard or thereabouts, including engineering expenses and everything.

Q. But I mean outside of the engineering expenses. Supposing you let the work to a subcontractor. Outside of the engineering expenses, what could you have it done for?—A. The engineering expenses do not amount to much—a cent or two a yard.

Q. Well, at this time, for instance, what could you get the work done for?—A. I suppose it might be done for something less than 15 cents. It varies, though. Enlargement work is very much more expensive than building new levees. I suppose 15 cents a cubic yard might be taken as a fair estimate.

Q. Please state what, in your opinion, ought the Government to do to perfect the levee system; in what way should it proceed, what appropriation is necessary, and how should the work be conducted.—A. In my opinion, a very reasonable estimate was made by the Mississippi River Commission in their last report. I mean the report of 1896. That estimated the yardage at about one hundred and twenty millions. I think that was a fair estimate.

Q. Do you remember at what price per yard?—A. I think they estimated it at 15 cents per yard, and the total cost at about $18,000,000.

Q. Do you think that would perfect the system?—A. I can not say that it would perfect it. My recollection is that it gave a margin of 2 feet above high water. I think that would be sufficient.

Q. Taking your levee district as a basis, what, according to your judgment, would be the cost of maintaining the levee system, assuming that you had it built in a proper manner, of sufficient height and strength? What would be the average cost of maintenance for a series

of years?—A. That is very difficult to state. Our last high water campaign cost us a hundred thousand dollars for our district alone. In a year of low water it would cost us absolutely nothing. So it is hard to say.

Q. You might state the elements to be taken into consideration in the matter of the expense of maintenance.—A. It would depend entirely on the stage of water. I suppose that you might perhaps calculate the annual maintenance of levees at—. You mean simply the maintenance?

Q. Yes; keeping them in order. That would involve, of course, the construction of new levees to remedy breaks.—A. Well it would be very hard to average that. I would hardly know how to do it.

Q. Suppose the levees in your district were built to such a height and of such strength as you would like to have them as an engineer to afford ample protection, what would you need for your annual expenditures to maintain those levees in a safe condition, say for a series of twenty years?—A. In my district, I should say we might, perhaps, have to spend, as we have done, something like a hundred thousand dollars a year for a line of 200 miles; say $500 a mile—something like that.

Q. Five hundred dollars per mile of levee?—A. Yes; something like that.

Examined by Mr. CATCHINGS:

Q. But suppose, Major, that the levees were so patrolled that there would be no private use of them, so they would remain as you left them when built?—A. I understood the Senator to include renewals from caving banks, etc., and of course high-water maintenance, which is a big item of itself. But that is a somewhat hasty opinion of mine. I would like to think that over.

Q. Well, if you built the levee, and there is no caving of the levee, it would stay forever, would it not?—A. Yes, of course, unless there is high water, and then we would have to maintain and repair it. During my administration about 40 per cent of our line has been renewed in the last sixteen years.

Q. By caving into the river?—A. Yes.

Q. Is that not owing to some extent to the fact that levees have been constructed in the first instance rather nearer to the river than they ought to have been?—A. Yes; that is true. When the levees were first built, they were small structures, only a few feet high, and they were located where it was easiest and cheapest and would protect the greatest amount of land. When levees were only 3 or 4 or 5 feet high, they ran them up close to the bank, and since that time our endeavor has been constantly to put them on more permanent locations. We are now going rather radically into that and building them in some instances a mile or maybe 2 miles back.

Q. Under this, as you call it, radical mode of construction, the percentage of replacement would not be anywhere near as great as in the past, would it?—A. No; it would not. And I will state, too, that one motive for setting the levees back has been to get an increased waterway for the discharge of the river.

Q. You would have a bigger flood basin?—A. Yes. It has been found elsewhere, in the experience of foreign nations, that that does cut a very considerable figure in the lowering of the water line.

Q. You get a bigger high water channel?—A. Yes.

Examined by Mr. BERRY:

Q. Captain, I heard a Senator say the other day that it would be

better for the country if the levees were all destroyed and there were no levees at all. What would be the effect in regard to the spreading of the water; how many miles out would it spread in times of high water if there were no levees?—A. I lived for a good while in an unleveed country and had an opportunity to see something about it. In such a situation as that none except the very high tracts of land are cultivable at all; it does not pay for any man to cultivate land that overflows even as seldom as once in three or four years. His whole fortune is at stake every year, and he can't afford to do it. In short, the country would be uninhabitable, in my opinion. The best answer to an argument of that kind is, why should people have built levees unless there was some use for them? They did not build them out of theory. It has been an evolution from a matter of necessity. People built levees because they needed them.

Examined by Mr. NELSON:

Q. What is the area of the Yazoo Basin that is protected by levees?—A. About 6,600 square miles, I think.

Q. And nearly all of it good tillable land?—A. Yes.

Q. First-class land?—A. It is very well drained land, contrary to the general opinion. It is very well drained and very valuable land.

Q. You have a lot of interior ditches there—the Yazoo and other rivers?—A. We have natural drainage, yes, as you say.

Q. And a great deal of that land is improved with plantations and farms, is it not?—A. Yes. I do not know exactly what percentage, but a very large part of it is.

Q. Now I will call your attention to the St. Francis Basin, as it is called. Taking Crowleys Ridge as the western side of it, state whether in your opinion it would be practicable at a cost reasonable in proportion to the enterprise to construct a reservoir that would be of any substantial and material value to protect the country below against floods.—A. I should think not. The fall in the St. Francis Basin is too great to allow its use as a reservoir. The fall in that basin is something about 1 foot to the mile, if I do not mistake. The fall of the river is about half a foot to the mile, but the basin slopes about twice as fast as the river does.

Q. Taking it from Commerce down to Helena, in your opinion, owing to the great fall, it would not be practicable to construct a reservoir?—A. I should think not. To use that basin at all as a reservoir it would be necessary to construct cross levees at intervals of 10 miles or so; because, as I say, the slope of the basin being this way [illustrating a sloping position], in order to hold any quantity of water at all you would have to build the levees very close together, and that would be inordinately expensive; it would not pay, in short.

Q. There are no places below where any such reservoirs could be built?—A. Not to my knowledge.

Examined by Mr. BERRY:

Q. If it were possible to make a reservoir of all the territory included within what is known as the St. Francis Basin and confine that water, would not the expense of putting it in there and keeping it in there, and paying for all the property that would be destroyed by such a basin, be greater than to levee the entire Mississippi River from Cairo down—to finish the levees?—A. Without making a calculation, offhand I should say it would.

Q. When you paid for all the lands which would be overflowed in those seven or eight counties in Missouri and Arkansas?—A. The St.

Francis Basin is very fine land, a great deal of it very admirable land, and it would be simply destroying it.

Q. Destroying seven counties in Arkansas and Missouri?—A. Yes. I should say it would probably be greater than the expense of completing the present levee system.

Examined by Mr. CATCHINGS:

Q. Has there not been very great improvement in the method of constructing levees within the last few years?—A. Very great indeed. I hardly know of any branch of construction in which there has been more improvement than in levee building. In my younger days the levee system was almost no system at all. It was rough in the extreme. They left stumps in the levees and everything else. There was very little supervision exercised; almost none. Very frequently the engineer never saw the levee from the date that he staked it out until he finally came over it and received it. Levees were small in those days, and they did not often break excepting from the water running over them, and they did not appreciate the necessity for careful construction. Now levees are built with as great care as a reservoir bank would be.

Q. Will you give some statement as to the care you take in building levees?—A. The foundation is, in the first place, prepared with very great care. Every particle of vegetable matter, all the leaves and branches and things of that kind, are carefully removed and the stumps are blown out by dynamite. The ground is very carefully broken with a plow so that the new earth may make a good bond with the old earth. The earth is put up in layers—when by wheel scrapers, 2 feet thick; and when by wheelbarrows, 1 foot thick. Careful inspectors are on the ground who see every shovelful that is delivered, as it were, so that no fraud is practiced. In fact, every precaution is taken to see that the levees are constructed of nothing but sound earth, which is the best of all materials.

Q. Did any of the levees built by the United States Government break during the flood of 1897?—A. Not in our district; I do not know outside of that.

Q. I have heard the statement made that no Government levee broke anywhere?—A. My impression is that some of them did break in Mr. Patrick's district, up in the St. Francis district. In my district all the levees that broke were old levees without exception. They were all old and unsound levees. I can not speak any further than of my own district, but of that I can speak positively.

Q. No Government levee broke in your district?—A. No; and no new levee broke, whether built by the Government or by the levee board. The levees that broke were all old levees, in my district.

Mr. TAYLOR. I would like to ask you, Major, whether the thorough work done under the Mississippi River Commission has not contributed largely to the improvement of the entire system.

The WITNESS. The first reform in levee construction came from the Mississippi River Commission. They were the inaugurators of thorough work on the levees. We consider that that was the beginning of the era of good work—from the work begun by the Mississippi River Commission.

Q. The two levee districts in Mississippi have authority to levy taxes, have they not?—A. Yes; within certain limits.

Q. Within the bounds of their respective districts?—A. Yes.

Q. The State of Mississippi contributes nothing to that end?—A. Absolutely nothing.

Q. So that all funds that go into the construction of levees in those wo districts (except such as the Federal Government contributes) are aised by local assessment?—A. Absolutely. The two levee districts f Mississippi comprise the Yazoo Basin, and they alone build their wn levees.

Q. What is the levee tax now in your district?—A. It amounts on he whole to about 2 per cent of the assessed valuation. That gives it n a compact form. It is raised in two or three different ways—by a otton tax, an ad valorem tax, and an acreage tax. But that is what t amounts to—about 2 per cent.

Q. And that is in addition to State and county taxes?—A. Yes; that s a levee tax pure and simple. Our district of four counties has an nnual income which it expends on levees of about $280,000.

Q. What is the bonded indebtedness of your district?—A. $1,150,000.

Q. That represents bonds issued and sold——A. For levee purposes lone.

Q. And the proceeds put on the levees?—A. Yes.

ON BOARD STEAMER MISSISSIPPI,
February 4, 1898.

WILLIS L. MOORE, sworn, testified as follows:

Examined by Mr. NELSON:

Q. Professor Moore, what position do you occupy?—A. Chief of the nited States Weather Bureau.

Q. How long have you held that position?—A. About two years and half.

Q. Were you, prior to that time, connected with the Bureau as an bserver or in any other capacity?—A. I have been connected with the ureau in various capacities for twenty-two years.

Q. And have done work as an observer?—A. As an observer, forester, professor, and so on.

Q. Did you, through your Bureau, in 1897, take steps to ascertain the ndition, movement, and status of the flood of 1897?—A. We did.

Q. Please, in a brief way, state what you did in that behalf, and ate the result of your work.—A. We have eighteen river centers, ach in charge of what we call a local forecast official.

Q. Can you name those centers?—A. Well, from Cairo down the Cairo istrict extends part way down to Memphis; then the Memphis district egins, and there is a Vicksburg district and also a New Orleans district. Each district is in charge of an official. The centers of the districts that we pass are at New Orleans, Vicksburg, Memphis, and Cairo. Ve have made a comparative statement of the precipitation that produced all the great floods since 1882, including 1882.

Q. State from what causes and sources came the precipitation that roduced those floods.—A. Judge Taylor and Major Starling have given ou a very accurate description of the origin and progression of those torms. I can only supplement that information a little. It is true hat all the storms that cause our great floods originate in the Lower Mississippi Valley or in the vicinity of Texas and Louisiana, and move northward over the Middle Mississippi Valley, over the Ohio Valley, and off eastward.

Right at this point I would like to give a brief description of the excessive precipitation, and the area on which it fell, that caused the

four great floods, beginning with the flood of 1882. The flood of 1882 was caused by excessive precipitation which occurred in January and February. That excessive precipitation varied from 1 to 12 inches, and it fell over the Ohio Valley, the lower half of the Arkansas Valley, all of the Red, and none of the Missouri Valley except near the mouth of the river. There was a deficit over the Upper Mississippi Valley and over almost the entire Missouri Valley.

Q. Less than normal?—A. Less than normal.

Q. In the Upper Mississippi and Missouri?—A. In the Upper Mississippi and nearly all the Missouri. There was a little excessive moisture fell near the mouth of the Missouri. I emphasize that fact, because later on you will find that the intense precipitation that causes all these great floods does not occur west of Kansas City, west of Fort Smith, or north of Keokuk. So you may eliminate almost entirely from the problem all precipitation that falls west and north of that region.

Colonel GILLESPIE. Where was the greatest precipitation?

The WITNESS. The greatest precipitation was over the States of Tennessee and Missouri in the 1882 flood. The precipitation that caused the flood of 1884 occurred in January and February. It averaged from 1 to 6 inches in excess of the normal rainfall. That excessive precipitation fell over the Ohio Valley, over the States of Missouri, Mississippi, and Arkansas, and Indian Territory. There was no excessive precipitation on the Missouri River at all, except at its mouth, and a deficit over the Upper Mississippi. Snowfall has very little to do with these great floods. The precipitation that caused the flood of 1890 occurred in February and March, and it varied from 1 to 9 inches in excess. That precipitation, or such portion of it as drained into the Mississippi River, fell over the entire Ohio Valley, over the southeast half of Missouri only, and over the State of Arkansas. There was a deficit amounting to from 1 to 2 inches over nearly the entire Missouri River, and a deficit of about 1 inch over the Upper Mississippi. As to the flood of 1893, the excessive precipitation that caused it occurred in April and May.

Q. That was later than the others?—A. Still later. The excess varied from 1 to 8 inches and fell again over the entire Ohio Valley, over all of Missouri and Arkansas. A marked deficit in this case, ranging from 1 to 3 inches, occurred over the whole eastern slope—over all the region between the meridian of Kansas City and the Rocky Mountains. The excessive precipitation that caused the flood of 1897 varied from 1 to 8 inches and covered the Ohio Valley, the State of Missouri, and the northeast half of Arkansas, and in this case a moderate excess extended up the Mississippi Valley, but not over the Missouri Valley, except in the Dakotas.

Q. When you refer to the Ohio Valley, you include the Tennessee and Cumberland rivers?—A. Yes. So from this it is seen that all of the great floods were caused by excessive precipitation over the Ohio and the middle Mississippi valleys, and that other precipitation is insignificant or unimportant in the study of the problem. The volume of water that fell immediately preceding the flood of 1897, it may be important to note, did not equal the volume, apparently, that fell in either of the other great floods.

Q. The volume of rainfall, you say, in 1897?—A. The volume of rainfall.

Q. But was not the snowfall greater?—A. No. This precipitation includes the snowfall. The excess of water that fell on the particular watersheds that furnish the drainage for all these floods was over twice as great in 1882 as it was in 1897.

Major HARROD. In the year when the Cincinnati gauge reached 71.2, think in 1884, was there not a very unusual condition prevailing ıroughout the Ohio Valley, the ground being covered with sleet? now had fallen and melted and frozen, and the rainfall was turned ose on this smooth sheet of snow and ice, and that gave the frightful se of 10 feet more than ever occurred at Cincinnati before.

A. I could not answer that question without looking up the records overing that period. If it is true that the ground was closed by freezıg, the water would quickly gather in the tributaries and main streams nd the freshet would become intense in a very short period. Whenver the ground is either saturated or frozen, whatever water falls runs ff very quickly.

Q. Where there is a great rainfall, then, it makes a difference whether ıe ground is frozen or not?—A. A very great difference. But it is ldom that you have frozen ground to consider except in the northern ırt of the Ohio Valley, where, as in 1884 (an exceptional case), you ight have had frozen soil to consider.

Q. Please go on and state what observations your Bureau took with ference to the flood of 1897 from Cairo down, and the result of it. ive us all the information you can on that point.—A. Our gauge eights below Cairo were higher by several feet than in any previous ood of which we have any record, although the volume of water carred away was probably less than in some previous floods. I think ıat is the only answer I can make to that question.

Q. Do you mean to say that the gauges at all the points along the ower Mississippi River showed higher than they had shown before?—.. They showed a higher reading than in any previous flood that we ave any record of.

Colonel GILLESPIE. How many points do you read?

The WITNESS. I can not give you all the points. We have a great ıany substations between our main stations. Our principal stations, ke Memphis, Vicksburg, Helena, and New Orleans, all showed an xcess. I do not think it possible that any intermediate points could ave shown a lower water, unless it may have been on some small tribuary some distance from the main stream. We have fifty or sixty readıgs outside of our regular stations.

Examined by Mr. GALLINGER:

Q. Professor Moore, you made a statement that at one of the preeding floods the excess was twice as great as in the flood of 1897.—ı. Yes.

Q. How do you account for the excessive high water in 1897 as comıared with the high water of that preceding year?—A. I would not ıant you to take my opinion in regard to that. I think the opinion of he engineers who have testified is much more valuable than mine. My usiness is to study rather the hydrology of this question than the hydrogaphy. But I believe it is due to the leveeing up of the stream; that he river is carrying away a given amount of water in a shorter time, nd, in order to do it, there must be a greater height of flood volume. do believe, at the same time, that that increase of flood volume tends) lower slightly the bed of the river, but it apparently does not lower so much as it gives increase to the flood heights. We have had durıg the last year or so a great many of our gauges inspected and paired, and have given special attention to the gauges from which we et our readings, and from a comparison of these gauges it does not pear that our zero of low water has risen. It is almost, it seems to e, definitely settled from examination of our gauges that the bed of the

river has not risen; that it has suffered probably a slight decrease. We sometimes in low water now (it seems to me more frequently than formerly) have below-zero readings—that is, the low-water reading is below the zero of the gauge—below the zero of the point that in former years we supposed was the lowest water known. I think that is conclusive evidence that there has been no building up of the bed of the river, notwithstanding the confining of this great volume to a smaller channel and throwing into that channel a much greater sedimentary deposit.

Examined by Mr. CATCHINGS:

Q. What was the year in which you said the excess was so great?—A. That was in 1882.

Q. Do you know how much water passed Cairo then?—A. I do not know the sectional discharge. The engineers have it here. We do not measure the sectional discharge.

Major HARROD. The calculation was that at latitude 32, the mouth of the Red River, there passed in 1882 2,200,000 cubic feet, and in 1897 about 2,000,000 cubic feet, a second. The gauge at Red River was a little higher in 1897 than in 1882.

Mr. NELSON. And the volume was less?

The WITNESS. Two hundred thousand cubic feet per second less.

Mr. NELSON. The volume was less, but the gauge was higher.

The WITNESS. The volume was less, but the gauge was higher.

Colonel GILLESPIE was then examined, as follows:

By Mr. CATCHINGS:

Q. What was the maximum discharge at Columbus in 1882?—A. 1,600,000 cubic feet.

Q. What was the maximum at Columbus in 1897?—A. 1,462,000 cubic feet. But, inasmuch as the discharge was not taken at the time of the maximum gauge reading, it has been computed that the probable discharge at that point was 1,590,000 cubic feet.

Q. What is the difference between the two?—A. About 10,000 cubic feet.

Mr. BERRY. Which was the greater?

The WITNESS. 1882.

Q. Upon that point, how do you account for the greater excess of the discharge in 1882, at the mouth of the Red River, than that which you give at Columbus?—A. In 1882 the Red River discharge was 1,590,000 cubic feet.

Major HARROD. That is the Mississippi. I included the Atchafalaya and the overland flow.

Mr. MOORE was then recalled and examined, as follows:

By Mr. NELSON:

Q. I should be glad to hear what steps your Bureau took with reference to the flood of 1897. As I understand, that was the first attempt of your Bureau to keep a systematic record of the flood?—A. No; this system has been of gradual growth during a number of years.

Q. But has not been carried on on such an extensive scale as during the last flood?—A. No.

Q. Please state what steps your Bureau took during the flood of 1897?—A. Well, we gave warnings all the way down the river to these flooded districts prior to the coming of the flood; and I have no doubt that many millions of dollars' worth of property were saved by such

notice. There is one problem here that I would like to go into the record, and that is in regard to the overflow of the St. Francis Basin. We studied that overflow very carefully. Prior to the break in the Yazoo Levee and the flooding of that great district, we issued warnings to the Yazoo Valley, entirely on the assumption that the return water from the St. Francis Basin would carry the levees protecting the Yazoo Valley. It was demonstrated a little later that that was a very accurate prediction. When the Yazoo Valley was filled with water we could see the extreme height already of water in the Lower Mississippi, and, prior to the return of the water from the Yazoo Basin, we made an estimate, and sent our warnings that the Tensas Basin would be overflowed. We concluded that the return from the Yazoo Basin of this great volume of water would make a break on the opposite side of the river from the point where it returned. This undoubtedly is an argument against the allowing of these basins to remain open. While the leveeing up of the basins and the confining in the main channel of the large volume of water that otherwise would overspread the St. Francis and the Yazoo valleys will, in my mind, give a much greater gauge height for a considerable distance down the river, it also will render the levees less liable to crevasses by not sending the water at an oblique angle across the stream when it returns from the overflowed area.

Mr. BERRY. Then do I understand you, Professor, that it would be safer to close them, notwithstanding the increased height, than it would be to leave them open?

A. Yes, unquestionably. I think if you had your levees along the Yazoo Valley at a proper height and a proper strength that the St. Francis Basin could have been leveed up and the entire volume of water carried away without any injury to the Yazoo Valley.

Q. That is on the assumption that the Yazoo Basin had been properly leveed up?—A. Certainly.

Q. Well, as I understand you, the precipitation was a great deal more in 1882 than in 1897?—A. Yes.

Q. But the height of the water in the river at all points below Cairo was much greater—— A. Much less in 1882.

Q. And you account for that by the fact that during the interval so many basins had been closed with levees—since 1882?—A. I do.

Q. And that had raised the height of the river?—A. Yes. Although I may say this, as qualifying that statement, that it is possible for a less volume of water to fall and produce a given height if it comes in a short period of time.

Examined by Mr. BERRY:

Q. You stated that it was possible for a less quantity of water to make a higher flood by reason of the fact that it came down more rapidly or quickly, as I understood you.—A. That is something that should be considered in measuring this great volume of water and in measuring the gauge heights.

Q. I will ask you if you think that the cutting off of the timber and the cane and the underbrush, and the cultivation of the soil, has anything to do with making it run off more rapidly?—A. There is no doubt in my mind at all that one way to restrain the floods is to restrict the flow of water on the watersheds; to restrict and retard the gathering of the water into the rivulets, and thereby to retard its movement to the main channels, and then to facilitate its passage by levees when it gets into the main channel. In other words, to restrict the flow on the watershed and increase the flow in the channel. You ask me whether

the cutting away of the forests has had anything to do with the augmenting of the floods. I believe it has. I believe the denuding of much of the Ohio Valley and some of the Mississippi Valley has tended to shorten the period in which a given amount of water will gather into the main stream, and thereby to increase the gauge height in the Lower Mississippi with the same volume of rainfall. There has been very much discussion over that problem. Many people claim that the cutting away of these forests has altered the climatic conditions and affected the rainfall. It does not alter the rainfall, but I think it does produce an increased height with the same amount of rainfall by allowing it to gather more quickly.

Examined by Mr. CATCHINGS:

Q. I see that on page 75 of your bulletin you call attention to the fact that whereas the maximum gauge at Helena in 1882 was 41.2, in 1897 it was 51.5, and you attribute that rise in the maximum gauge at Helena entirely to the fact there had been some levee building along the St. Francis front. Now, in 1882, when the maximum was 41.2, the White River Basin had not been leveed at all, and the levees had broken all along the Yazoo fronts, so there was an outflow of water into the Yazoo Basin and into the White River Basin. Now, is it not fair to consider that fact in trying to account for the difference between the gauges of 1882 and 1897?—A. Oh, yes; there are a great many disturbing factors that may enter into the consideration of the problem.

Q. In other words, did not the fact that it was all leveed below there in 1897 cut a very material figure in the matter of raising the water at Helena?—A. The leveeing of the river probably raised the height of the gauge readings.

Q. So that that ought to be considered in determining the matter?—A. Yes.

Examined by Mr. NELSON:

Q. Well, I call your attention again to this matter about which I asked you—a reservoir at the St. Francis Basin. What would you say about that, bearing in view the matter of expense and the feasibility of it?—A. I will tell you frankly that I had an idea before listening to the testimony of these engineers that it was practicable, that it was possible to create a reservoir in the St. Francis Basin; but I will say now that I do not think so. In fact, I do not consider myself expert enough to properly answer that question, and I am compelled to defer to the opinions of men who have made that a life study.

Q. Taking into account the course of the precipitation and the sources of rainfall, is there any other point where it would be feasible and practicable at moderate expense to give any relief by means of reservoirs?—A. There was a theory espoused by quite an eminent gentleman in Washington that the creation of reservoirs along the Missouri River would accomplish that purpose; that the taking of 1 acre of land for reservoir purposes up near the head waters of the Missouri and along down to the middle of its course would save several acres at the mouth of the Mississippi. Of course the fallacy of that theory is indicated by the fact that the rainfall or snowfall at the head of the Missouri has nothing whatever to do with these floods. In further answer to your question, I know of no region where it would be possible to create a reservoir unless it be at the St. Francis Basin.

Q. There are no points below?—A. Not that I know of.

Q. Have you given any attention to the so called outlet system or the jetty system; are you familiar with that?—A. No, I am not. I would not be competent to speak on that.

). Bearing upon this question of floods and how to relieve against m, are there any suggestions or is there any advice you can give committee as an expert on this subject?—A. I think there is nothing are to say, except to make the general statement that in studying floods of this region with a view to giving warning of disaster I am re and more impressed with the idea that the lower levees should be sed and strengthened and the levee system should be continued so to close all basins all the way up.

). Beginning from below and strengthening them upward?—A. ginning from below and strengthening them northward. For the t time in the study of this problem there is presented by the recent ort of the Weather Bureau for the study of the engineers accurate cipitation data on the watersheds, and it is presented in such a y as to be segregated from all other precipitation. In other words, give the excess which precedes each of the great floods, and we give n such a way that one excess is comparable with the other excess. vould like to emphasize the importance to the engineer to-day, in ing plans for future improvements on a permanent basis, of the eful study of these precipitation charts. I believe they have not n given sufficient weight in the past.

o properly study a flood one should begin at its source; he should in with the precipitation that causes the flood, and he should have urate knowledge of the extent of the precipitation and the areas ich it covered in order to get a proper measure of the volume of er which must be carried away. This should be done before one empts to determine the height of the levees that are to be con- icted in order to protect the surrounding country. By an examina- n of the precipitation preceding the flood of 1882 you will find that flood of 1897 was only of about four-tenths the volume of the flood 1882, but by a further examination of these charts you will find t that four-tenths fell inside of a period of about thirty days, thereby menting its intensity and making it equal, as a flood producer, to e volumes of water that had been much larger and had fallen dur- a greater period.

n summing up, I wish to say that I believe there should be a height ot less than 6 feet in the levee below Helena and Memphis above high-water mark of 1897, in order to carry away the volume of er that, from a study of these precipitation charts, I believe you l have to handle at some time in the future.

olonel GILLESPIE: Did you say that the precipitation of 1897 was y four-tenths of the precipitation of 1882?

. About four-tenths of the precipitation of 1882, but it fell in about half the time. I mean the excess of precipitation which caused floods—the excess above normal.

U. S. S. MISSISSIPPI,
Helena, Ark., February 4, 1898.

laj. J. J. HORNER testified as follows:

entlemen, in behalf of the chamber of commerce of this city, I desire xpress their gratification that the Government has seen fit to send a mittee, and to send you honorable gentlemen, to investigate the ssissippi River. We regret exceedingly that you can not be here in light, when we could probably better show you our needs and the antages which would result to the Government from the improve- nt that they have undertaken here. But we know that your time is

valuable and that you are needed in Washington, and we can only express our gratification that you have called here and given us an opportunity to lay before you to some extent our needs. I would rather hear from some of the gentlemen who represent specially the levee interests.

Mr. GREENFIELD QUARLES, president of the Cotton Belt District, testified as follows:

Mr. Chairman, we were in hopes you would be able to be here in daylight, so that you might see the work that has been done on the levees. It is useless for me to go into a discussion of this question and give you the topography of this country. The engineers have furnished you with that data.

I have been living on the Mississippi River since 1851, and I owe my education, so far as the water is concerned, to seeing the water line gradually come up.

The question of the leveeing of the Mississippi River is one of science, as you all know, and the engineers have given it a great deal of study. I have thought of it some. I have no doubt in the world but that the Mississippi River can be leveed. I have no doubt in the world, after giving the matter study, and the flood of 1897 has convinced me, more than anything else, that it can be done. I believe that everyone who has studied the matter at Helena has come to the conclusion that the amount of water that passes Cairo can be held; the same amount of water could be passed at Helena and on down the river, with the levees as high as they are now contemplating, and as high as they are being built here in this district, and the next overflow that comes, a foot higher than it was before, there is no doubt of holding it.

My attention has been given to levees particularly on what you know as the White River front. We have our local levee districts here. They are divided into localities, but the Government knows it as the White River front. The White River front extends from Helena, where the high ground touches the river, until you get as near the mouth of the White River as you can.

Mr. NELSON. There is a ridge here that projects up to the river, between the St. Francis and the White River basins, is there not?

The WITNESS. Yes, sir; that is Crowleys Ridge. This is the end of Crowleys Ridge.

Mr. NELSON. Your town is on the south side of that ridge, is it not?

The WITNESS. It is on the east side and right at the foot of it, east and south. In fact, the ridge extends probably a mile south of this town. This is the only place where the high ground touches the Mississippi at all on the west bank of the Mississippi River.

Mr. NELSON. On which side is the St. Francis here?

The WITNESS. The St. Francis empties into the Mississippi about 8 miles north of this place, and it follows right along that edge of the ridge most of the way, and then turns and comes right into the river. Crowleys Ridge is only about half a mile, at the mouth of the river—maybe not half a mile—from the Mississippi River. Now, as I say, it has been demonstrated to us, at least we believe, that there is no doubt but what we can levee and pass all the water that comes into the Mississippi River from Cairo down, or any other place, and carry it down through with the levees that we have. A great many have contended to you that we can not levee the Mississippi, and a great many that have not studied the subject say that you can not levee the Mississippi River, and a great many complain because the levees break once in a

. It is useless for me to say that there are 1,300 miles of levee
nly 2 or 3 miles washed away during the last flood. But here is
the people want; they have taxed themselves and have done all
can to build levees—not that they intend stopping taxing them-
s, but they believe now that there ought to be one general system
ees on the Mississippi River, and they believe that the levee sys-
f this country ought to be put in the hands of the United States
rnment. They have implicit confidence in the ability and in the
s that have been selected and carried out by the Mississippi River
nission. They believe they understand and know what they are
; and they believe that the mode that they have selected will
y result in the triumph of saving this Mississippi Valley from
low.
ould go on and tell you about the value of this Mississippi Valley
ry to the Government, but you know that and your statistics fur-
you that. The people of this Mississippi Valley produce more per
agriculturally than any country in the world, and they consume
than any country in the world. Go out here on a cotton planta-
and take a common plantation nigger, and he consumes more in a
than most any laborer you will find anywhere; he will have it and
nsumes it, and we get what he consumes from other parts of the
try. It is a notorious fact that they raise very little of it. And to
ct the country, as a question of interest and nothing else, it does
to me that it would pay the Government and is the duty of the
rnment to protect this country, because it will pay back, in the
s that will be raised by the protection of this country—it will pay
big in the consuming that the people here do.
. NELSON. Your chief crop here is cotton, is it not?
e WITNESS. Yes, sir.
. NELSON. Are you now engaged in building a levee in front of
?
e WITNESS. Yes, sir; and that is the reason I wish you could be
in daylight.
. NELSON. How high are you making that levee—how high above
round?
e WITNESS. In some places it is 30 feet.
. NELSON. Above low-water level how high do you calculate it
?
e WITNESS. It will go about 54 or 55 feet above low water, and we
o have it about 3 feet above high water; that is, the levee that is
being built.
. NELSON. And how high do you say above the level of the
nd?
e WITNESS. Well, that depends on the topography of the country.
. NELSON. Well, right here, for instance.
e WITNESS. Right here it will be about 15 feet, I would say, right
—the lowest part.
. NELSON. When completed?
e WITNESS. Yes, sir. We had the most disastrous break right
r Helena here, about 2 miles, that I reckon has ever happened
e Mississippi River, except one. It was a very peculiar break. It
very near the bank of the Mississippi River, and it broke into a
—something that very seldom happens—and it washed from the
ssippi River into that lake.
. NELSON. What is the name of that lake?
e WITNESS. That is called Long Lake. It washed into that lake,

and, in order to cover that, we had to build around entirely and go across that lake. Now, we have nearly completed that, and when we get that done we will have a continuous line of levee of about 28 or 29 miles. Then there will be a break in that for a short distance, because we have not had time——

Mr. NELSON. Are you in the White River or St. Francis district?

The WITNESS. We are in the White River district. The St. Francis district ends at the mouth of the St. Francis River.

Mr. NELSON. Now, will you please tell the committee what proportion your local district or your State has in the past contributed toward the construction of the levees, and how you raise it?

The WITNESS. Our engineer will follow you and give you the proportion. I can only give you the present tax that we levy. I am secretary of the Cotton Belt District No. 1, that is in this county exclusively, and lies about 30 miles below here. When we first taxed, the first time, we levied a 9 per cent tax on the taxable real estate; then the next time we levied 5 per cent on the taxable property.

Examined by Mr. NELSON:

Q. Is that on a high valuation? Is that on about what you could sell the land for?—A. It is more than we have been selling it for. We value cleared land $25 an acre; woodland we value not lower than $1.50 an acre, and a great deal at $2.50.

Q. And on that valuation you made an assessment of 9 per cent?—A. Yes, sir. Then we made an assessment of 5 per cent, and then 3 per cent, and since then and from now on we expect to continue to make a levy of 2 per cent on the valuation.

Q. Have you any idea what you have expended in this White River district?—A. Our engineer will accompany you to Arkansas City, and he will have that data. We are levee men here. We have lived here before the levees, some of us, and lived here during the levees, and we believe that the only salvation for this country is to have them, and we believe that they will be a success, and as soon as we get them completed up to the grade that we are now going—as was said before the Mississippi River Commission in New York two years ago by some of the engineers who are now present—after the next high water we could tell a heap more than we knew before. That was two years ago when I heard that remark made by the engineer. They said, "We will have to learn about these things." Now, we have had that high water and we can tell exactly how high the levees are to be, and the reason we know that is by measuring the water that passed Cairo and the water that passed the capacity of the river to carry it at different points. We believe that we can carry all the water that passed Cairo by the levees as we contemplate building them.

Q. In 1897 the water was higher here than ever before, was it not?—A. Yes, sir; it was 3.85 feet higher than ever known here before.

Q. Nearly 4 feet?—A. Yes, sir.

Q. And did the same proportion continue below?—A. That is very peculiar, sir. It was greater to a certain distance—about 16 or 18 miles—below here, and then it fell off again.

Q. How many crevasses were there in the White River Levee—what is known as the White River Basin?—A. Our engineer will have to give you the number of them, sir. In my district there were three. There is another local district below that, and Major Purvis can give you that exactly.

Q. Did it entail much loss and destruction of property?—A. A great

deal, sir, because, as I told you, the crevasse that we had here at Helena was an unprecedented one, and, by washing an inroad in there of about 30 feet, the water went in with such great force and depth that it entailed immense damage. But I will state, sir, that our people went to work as soon as the water went down and made one of the finest crops we ever made, and they are not disheartened, because they believe the Government is going to keep the levees up with the aid of their taxation.

Q. Your idea, then, would be that it would be better on all sides to let the Federal Government assume jurisdiction and take control of the subject?—A. I fully believe that, sir; and I believe that this entire community, and, in fact, the State of Arkansas, thinks so.

Q. And on that theory your people, I suppose, would be willing to contribute something—to continue to contribute?—A. Yes, sir; more than willing. Our idea is this: That the Government should have control. Now, in little local matters sometimes one man wants the levee to come near his place, and another man wants it to come somewhere else, and the Government must decide those things. It may be necessary sometimes, before we get the system of levees completed, that they must let the water go in one place and keep it out from another.

Q. And you think the Federal Government would be less subject to these local conflicting interests?—A. Yes, sir. In other words, when a Federal engineer comes here and says this levee shall be built, it will be built. When they say another shall not be built in a certain place, it would not be built. They would be supreme.

Q. And your people would prefer that than to continue under local management?—A. Yes, sir. I happen to be a member of the Arkansas legislature, and I expect to introduce a bill in the next legislature, and I think it will pass, giving the Government all the authority they will take in the matter.

Q. And still you would expect to contribute?—A. Yes, sir; we will be glad to do that. We maintain a telephone line, and we can not get along without that when there is trouble; we put men to work at a certain place, and telephone backward and forward and move men with rapidity and supplies to protect any break.

Q. Did you have much of a struggle here in 1897 to protect your own?—A. Well, I remember seeing Colonel Gillespie and Colonel Stickney here at that time. It may sound like egotism, but I believe there has never been such a struggle as we had here. I suppose Major Starling had the same trouble; but we had to sack our levee and build it up 4 feet in a great many places.

Q. How long did that intense struggle last that you had? How many days?—A. Well, it seemed to us a thousand years, but I think it lasted about three weeks.

Q. And your people were at work all the time?—A. Every man.

Q. Fortifying the levees?—A. Every man, white and black; and these men that you saw here—a great many of them lawyers and doctors and ministers—everybody was out there filling sacks, with spades and shovels in their hands, and carrying them with their own hands onto the levees; and they struggled that way until finally the levee broke. The levee gave way first at Flower Lake, and we thought we were safe, because it began to fall very rapidly as soon as it gave way, but the immense crevasse we had here broke within an hour.

Q. Flower Lake is above?—A. Right above us.

Q. On the St. Francis?—A. No, sir; on the Mississippi.

Q. Across the river?—A. Yes, sir. We raised the levee; we did not

prepare for 4 feet of high water above the high-water mark that we had had before; it would have held that without any trouble. But we built that levee that distance—our whole levee district, about 28 miles—and we put sacks all the way along, and some places they were six sacks high. It looked very much like a fortification.

Q. That work was done largely under your local jurisdiction?—A. Yes, sir.

Q. And by local means?—A. By local means, most of it; yes, sir.

Q. I mean it was done outside of Federal help?—A. Yes, sir; outside of Federal help.

A CITIZEN. It was supplemented by the Government.

The WITNESS. Yes; it was supplemented by the Government, but all this work done around the city of Helena, and a great deal of the work done down in the district, was done by local help. It was supplemented by the Government. There was some work done down below by the Government, but is it too much to say that we spent $40,000 on that? I think we spent more.

A CITIZEN. We used 220,000 sacks.

Q. How large is your city, here?—A. We have 7,000 inhabitants.

Q. You are the county seat?—A. Yes, sir. About half are white and about half are colored.

Q. And without levee protection here you would be absolutely at the mercy of the flood, would you not?—A. Yes, sir; we would. A great many of the residences are built back on the high ground, but all the churches, all the manufacturing industries, all the stores, and the school-houses—everything of that kind—would be absolutely at the mercy of the flood.

Q. Outside of storekeepers and such, have you any manufacturing enterprises here?—A. We have three oil mills; we have a box factory; we have two or three sawmills; we have two compresses; we have an ice factory, gas works—Major Horner will follow me, and he can give you those statistics better than I can. He is at the head of most of those public enterprises. Have I left out anything?

A CITIZEN. Well, all the railroad tracks.

The WITNESS. All the railroads that come in here are protected by the levees.

Q. How many railroads have you?—A. We have three: The Iron Mountain and the Midland and the Illinois Central across the river here; they have a depot here. This year, I reckon, we will handle 75,000 bales of cotton at this place—we will handle over that; we have already handled 71,000, Mr. Miles tells me, and we will go over the figure I gave, because it has been a very hard season. A great deal of the cotton is in the field yet, still ungathered; on account of unprecedented bad weather we have been unable to gather it; they are gathering it now.

Q. But that does not spoil it, does it?—A. Well, it detracts from its value. By having it out that long it stains it.

Q. But it does not render it unfit for sale wholly?—A. No, sir; it can be sold, but it gets dust on it.

Q. And it brings a less price?—A. Yes, sir. I am sorry to have to detain you so long, gentlemen. I will simply say, as in the beginning, that we are anxious for the United States Government to take charge of the Mississippi River. We believe that they can, and we believe that they will, protect us if they will follow out what has been already demonstrated by the Mississippi River Commission. We believe it is one of the greatest enterprises the Government has ever taken

charge of. We believe that the Government only can protect the country as it ought to be protected. Building a levee at one place and not building it at another, and ruled over by a local levee board, we will never have that protection that the Mississippi River country ought to have, and I do not believe that we can get that protection in any other way than as a national enterprise.

Q. Your theory, then, is that the Government should complete the whole system, from Cairo down, and take jurisdiction of it?—A. Yes, sir; complete it from Cairo down, and follow it up as experience and science may teach them, and have entire jurisdiction of it. And the only thing they would have to do with the local levee boards would be in the local levee boards assisting them to hold the interest that people have when they pay for something, and to assist the Government; because I think that is right, I think that they ought to contribute to it, and I think they ought to contribute liberally to it; because, when we get that protection we will have a country here unexcelled by any in the world—the most productive country in the world. And we are willing to devote our means—what we call "liberally"—2 per cent tax. Our entire taxation for city government and county and everything else is only a little over 2 per cent, and we contribute that now—this 2 per cent.

Q. Two per cent specially for levees?—A. Yes, sir.

Q. On the valuation you have given, I think that is a big tax.—A. Well, we are anxious to contribute. We think we get amply repaid for it. But, as I say, while we believe that the local levee district that I am secretary of—I believe that that might be maintained; just that particular one might be maintained; at the same time we never can have a thorough system of levees on the Mississippi River unless there is some ruling power—some one power that controls the whole system; and we believe that the best power to control that is the United States Government.

Q. Would it not be a good plan for all the States to do what you propose to do in your legislature—pass similar acts?—A. I think they will do it, sir, though I am not advised.

Q. Well, but do you not think it would be a good plan for all the States to have the same legislation that you propose to secure here?—A. Yes, sir; I think it would be a good plan.

Mr. GALLINGER. Will you state precisely to the committee what this statute contemplates—the bill you propose to introduce.

A. Just to give the United States Government authority to build and control the construction of these levees. Now, of course there are some questions of law there that would have to be discussed—as to what authority we could give. That is a question that will have to be discussed and considered. For instance, we have a statute on the statute books now that has been there for a good many years that makes it a felony for anybody to make a cut-off in the Mississippi River. Now, I do not pretend to say whether they ought to have cut-offs or not, but if the engineers of the United States say that they ought to have them I think those engineers ought to have the authority to make them. And all the authority that the State of Arkansas can give, I believe, they are willing to give to the Government to take charge of the levee system; and I believe they have the power to give the authority.

Q. You would be willing to concede your levees and rights of way and turn it over to the Government?—A. Yes, sir; and all in the world that we would be called upon to do would be to contribute our share of the tax every year to the keeping up of these levees, and be guided

exclusively by the United States Government. Then we would get out of any little local matters—little jealousies—that we might have; things of that sort that always grow up more or less.

Q. And you would be better able to construct your new levees back in the proper place?—A. Yes, sir.

Q. I suppose the difficulty you have under local administration is that the landowners want to get as near the river as possible?—A. One man would want the levee to go at a certain place with reference to his plantation, and bring influence to bear to have the levee located where he wanted it located, when it ought to go some other place. And the Government could come in, entirely disinterested, and no one in the locality could say, "This is the place where the levee ought to go," and have it put there.

Maj. J. J. HORNER testified as follows:

I have listened with a great deal of pleasure to the questions that have been propounded by the chairman to Mr. Cowles, because it indicates the line of inquiry you wish to follow.

I have lived on the Mississippi River so long that I am sometimes a little ashamed to tell it; it has been since March, 1836.

Mr. NELSON. You started here, then.

The WITNESS. Not quite. But I have lived on the Mississippi River that long, and I have lived in this place that long. I have seen the levee system from its inception to the present time. I remember the first levee that was ever built in this country. It made an impression upon my mind, because it was paid for in "shinplasters" of J. P. C. Dolliston. It was in 1839. The levees for a long time, up to 1850, were the subject of private enterprise. They were donations. There was no order or system to it.

Under the swamp-land grant by the United States Government to the various States in 1850 there was an effort made in the State of Arkansas to develop a system of levees, one which, probably, in its inception was good; but the spirit of speculation in lands overshadowed any system of levees, and the fund was wasted without obtaining any general system of levees. Levees were built here and there, and they were useful. But I have seen the water rise here at Helena higher and higher as the levee system has been developed more and more. A great many people have attributed the continued rise of the river to the action of the advocates of levees. I was once of that opinion myself; but I have changed it. When I saw the Ohio River in 1884 rise 7 feet higher in Cincinnati than anyone believed it ever could go, when it flooded the gas works and flooded their waterworks and paralyzed the city, when I was sent to bed in the boarding house with a candle and not even permitted to keep the candle because there were not enough to go around, I realized that waters rise higher than before known, in other streams, from other causes than levees. Now, while the levee system upon the Mississippi River has probably aided in making the water higher and higher, yet the development of this country, the clearing up of its forests, the surface drainage that has been improved from time to time, has also, in my judgment, added greatly to it. And we can never have any proper system of levees on the Mississippi River, as broad and as long as it is, unless the Government takes hold of it. Mr. Quarles has well illustrated some of the benefits that will come from Government control when he says that local influence often induces the location of the levees in improper places. That is true. I have seen it all my life. If the Government engineer comes here and demands of this levee board that they obtain a right of way

n a certain line they have no discretion. And it will be, as I have een it within the last six months.

Q. Are your local authorities in the habit of furnishing the right of ay or the location of the levee to the Government?—A. Always.

Q. Free?—A. Always. The Government demands that the right of ay be furnished before they will enter upon the construction of any vee, and that has to be done. They not only demand it, but they esignate the place now where the levee shall be located. That is cerinly to the advantage of these gentlemen who constitute the levee oard, because, when they go to their neighbor and say, "The levee must ome here, and we must have this much of your plantation," they can ay that they have no discretion; that they are sorry it inconveniences iem, but such is the condition on which the levee is to be built.

Our people have been generous, as has been well said, in the matter f applying their means to the construction of levees. They have volunarily taxed themselves to their ability, and yet, with all that, they have ot been able either to keep up these levees or to maintain them. I hink it is highly probable if the levees were once constructed, that, ith the local taxation here that would not be onerous upon the public, hese levees might be maintained under the supervision of the Govrnment; but to develop this system and to construct it now is beyond he means of these people. Take all this White River front; a large porion of it is a wilderness now, because it has been subject to overflow.

That country, which was a wilderness when the Government took old of the levees and constructed them down in the Laconia district, rior to the high water of 1897, hundreds and hundreds of men took p land and entered upon it for the purpose of actual settlement and ultivation, and they were there when this flood came over them; but hey are not disheartened now, because they believe that once the Govrnment has entered upon it that she will not stop until the system is ompleted. You will find that all over the Mississippi Valley. Those ands, while they were as fertile as any in the State of Arkansas, were o subject to inundation that they were forfeited to the State for nonayment of taxes, and were donated by the State for actual settlers.

Q. These lands, then, in the White River Basin were originally State wamp lands and were sold, and were then forfeited back to the State or nonpayment of taxes, and now your State donates them to actual ettlers. Is that it?—A. That is not the condition of all of them.

Q. No; but of a part?—A. Yes; of a large part of them. A large art of them were forfeited to the State in the early settlement of this ountry. A large portion of those lands were entered from the United tates Government. Those right along the bank of the river were setled, and prior to the formation of the cut off here—which is known as he Horseshoe Cut-off, and which was made when I was a boy—the ower part of this county, 40 or 50 miles below here, was one of the ost fertile and valuable portions of the county; but when that cutff was made it decreased the water here and increased it there, and ose lands were abandoned by the owners. Subsequently the other nds were sold by the State under the swamp-land act, and all those nds—99 tracts in 100—were forfeited, since the war, for the nonpayent of taxes, and have been subject to donation and have been donated.

Q. By your State?—A. By our State; and the State offers them to ettlers if they will come in there and cultivate them. It is for actual ultivation and occupation; occupation of them for three years acquires title without the payment of anything except the fees of the officer. nd this land has been taken by those settlers because they believe,

as I said before, that when the Government once enters on this work it will not desist until the lands are reclaimed and fit for homes for the people. You will find that hundreds of the colored people have gone in there and acquired homes because of their faith in the Government. Now, I want to call your attention to another peculiarity of this country. West of here, in Monroe County, in the southern part of the county, was once one of the most fertile countries I have ever known. Land sold there since the war for $5 an acre. Those lands have now been subjected to inundation 6 to 8 feet deep until the people were absolutely driven out from there.

Q. How long has that lasted?—A. It commenced about fifteen years ago and has gradually increased. Now, I want to call your attention to another fact—that those people living there (and Senator Berry is more familiar with it than probably other of you gentlemen are) applied for permission to sue the Government for the destruction of their homes because they had contributed to the building up of the levees through this Yazoo Delta and thereby, as they claimed, increased the flood upon them. The building of this levee restored that country down there.

Q. You mean the building of the Yazoo Levee?—A. No, sir; on the White River front.

Q. Oh, yes; several years ago.—A. Several years ago. It took the water off from them entirely. And there is not a more fertile country in the world than that. And those people went back there—have gone back in the last two years and are rehabilitating their homes. This year they were flooded, but the flood went off, and like everybody we have had a propitious season and they have made good crops. And that country that was flooded—as they claimed on account of the Yazoo levees—will be entirely relieved. I call your attention to that to emphasize what Mr. Quarles said as to the necessity of the Government taking it and making it a complete system. For certainly it would not be just to one side of the river to help the other side only; and whether the levees did it or not, it is not the duty of the Government to do that which in the minds of the citizens confirms them in their belief that they have been wronged by the Government. And if the Government takes hold of it at all, if they make appropriations for levees at all, I think it is the duty of the Government to take hold of the whole system, and do equal justice, as it always does to all its citizens in every public work, because I hold that the Government starts out to do exact justice to its citizens. They may not feel it at the time, but they will realize it when the system is completed.

And I believe that no greater work has ever been done by the Congress of the United States than the establishment of the Mississippi River Commission and the developing and putting upon record the facts and figures in regard to the Mississippi River. It is the first time and the only time that the Government has undertaken to demonstrate to the people here and teach them what were the causes of the floods and how they could be remedied; and they have but just entered upon it. I hold that it is nothing derogatory of the levee system that there were crevasses all along here, because the works of man are not permanent. I do not care who builds these levees, there will be crevasses from time to time; but the crevasses will be local in their damage, and if the levees are not built the damage will be general, and the Mississippi River must be abandoned. But look at the great wealth that is in this bottom. Consider it for a moment, and then consider its possibilities. And nothing can be done by the Government that will so upbuild this country as the reclaiming of the Mississippi Valley from disastrous floods.

Examined by Mr. CATCHINGS:

Q. In your judgment, could this Mississippi Valley country be inhabd without levees?—A. No, sir. I lived here when there were no ees; and, while people say that it was inhabited—it was inhabited. it how was it inhabited? It was here and there on the banks of the ssissippi River, where people cultivated the high points, and they ed by selling wood to the steamboats. That was the character of the abitation; the balance of the country was a wilderness—was a sturage for cattle.

Q. Lands lying back from the river, which are lower than those in nt, were not occupied at all?—A. Very little. Look at this country low here (and I know its settlement from the beginning of it, since 36). Here and there there were settlements along the bank of the er, but that was all. Occasionally a ridge—Old Town Ridge that ns around here evidently once was the bed of the Mississippi River; ound that there were settlements, but beyond that there was nothg. In my boyhood, on the Mississippi, everybody moved up and wn the Mississippi by sail boats, they had no packets, and everybody eded his boat, because there was no other means of getting about, d most of the people lived on the banks of the Mississippi River.

Q. Is it not a fact that the railroads that have come into this valley ve come only since it became manifest that the levee system would me day be completed—since it became manifest that we were all in rnest about protecting the country against floods?—A. That is true.

Q. And could those roads exist with the levees down?—A. No, sir. 1884 I was in New York, and I know Mr. R. P. Wilson personally, o built the Yazoo and Mississippi Valley Railroad, and in conversan with him I was congratulating him upon his location of it, and he nt on to express to me then that he had built it against the advice those whose good opinion he valued. But he said when that railad was built they were going to make an effort to keep up the levees; had to keep it up; and that levee was built there [pointing] and came a system by and through the business management and the edit that that railroad gave to it.

Q. You mean the northern Mississippi district?—A. Yes, sir.

Q. Mr. Wilson took the bonds of that district?—A. Yes, sir.

A CITIZEN. He took $500,000 at one time.

The WITNESS. But look at the Little Rock and Memphis Railroad. s history teaches that they struggled there for years and years ainst all adversity because they had no levees.

Q. Well, Major, you have lived there so long and have had such an telligent acquaintance with this district, I would like to ask you this estion: First, is it your judgment, and second, so far as you can learn, it the consensus of opinion of the people who do live in this country, at the only way to protect the country is to build levees?—A. That my judgment.

Q. That is, that is the consensus of public opinion with reference to at?—A. It is as to this portion of the country.

Examined by Mr. GALLINGER:

Q. Major, how great an acreage of swamp lands did the State derive m the National Government? Can you recall it, approximately?—No; I can not. I have not thought about that in years; I have own it; but it was a very large quantity.

Q. Do you recollect what that was sold for at the time it was sold to tlers?—A. It was sold for 75 cents an acre when it was within 10

miles of a navigable stream, and 50 cents an acre beyond that. I am pretty sure that that is it.

Q. You could not state with any definiteness to the committee what amount the State derived from the sale of those swamp lands, could you?—A. The State derived nothing. I will explain why they derived nothing. They endeavored to let levee contracts. Levee contracts were let, and they issued swamp-land script for the building of the levees, and the lands were sold for the swamp-land script, and the State actually derived no benefit from it.

Mr. NELSON. And the levees did not amount to anything?

The WITNESS. The levees were built not in any general system; they were built here and there as local influence could induce a contract to be let, and a very large amount of it was expended in nominally draining the country—in ditching; it was provided for levees and drains, and a very large portion was spent in the draining of the country; script was issued for all that, and that went in as the lands were taken up for the script. I apprehend there was not 100,000 acres ever sold for money.

Now, there is one thing to be said about the levee system under the State. While it was done in a very imperfect way, yet there was no statistical information about water then. Men went out and got the high-water mark from the marks on the trees.

Mr. NELSON. And built at random?

The WITNESS. And they built at random. Now you get that information from the knowledge that has been accumulated by the Mississippi River Commission and the statistics that they have on file and that can be consulted, but in those days there was nothing of that kind; the engineer went and looked on the trees and saw there what the high water mark was. Very often the levee was built 2 or 3 feet below high-water mark, because, when you offered an obstruction here to the flow of water the water accumulated, and the consequence was it went over and the levee washed away. That is the history of the country. There were no levels taken to build by, except the marks that were left by the high water, and everything was done in a very crude way.

At Helena, Ark., February 4, 1898, a number of citizens of that city visited the committee, some of whom, at the request of the committee, stated their views as to problems connected with the Mississippi River. Among these citizens was Mr. J. E. Miles, who, after having stated that in his opinion it would be advantageous to straighten the river by making cut-offs at bends, and certain reasons therefor, was requested by the chairman to submit his views in writing, inasmuch as the *Mississippi* was about to leave Helena for the lower river.

Mr. Miles subsequently submitted the following paper:

I will first state that I was born on the bank of the Mississippi River, in the county of Chicot and then Territory of Arkansas, on the 16th of September, 1823, at what is called Craigs Landing on Captain Ockerson's map of the river. My father, Benjamin L. Miles, settled on the land on which I was born in 1818, where he died in 1839. I was absent from the State four years and returned in 1843, in the fall before the high water in 1844, and have watched and studied the river closely ever since.

I sold my plantation in 1856 and settled in Helena in the spring of 1858, just before the high water of that year. The spot on which I was born caved into the river some fifty years ago. An examination of the river committee maps will show that I was born on the most crooked

ırt of the river. Whether I took my notions from that fact or not, I ıve always advocated straightening the river, or, as Captain Flad, of e river committee, stated before a committee of Congress, "short-ıing" it. In his statement in regard to the Rhine, where he was ɔployed, he says they made 28 cut-offs and lowered the flood surface ıme 5 feet. Apply this same plan to the Mississippi and it would have greater effect on most of the river than that. I have always held to ıe opinion that a straight ditch drained better than a crooked one; ıt the river committee seem to think the more crooked the river is ıe better it will carry off the water.

We have two objective points to work by—Cairo and the Gulf. The istance from Cairo to the Gulf is about 550 miles in an air line, and ɔout 1,060 by the river. I do not claim that the river can be made ;raight, but I claim the distance can be reduced to 900 miles, and by ırning the river through the Atchafalaya at Red River it can be ɛduced to about 800 miles.

It would take too long a statement to argue all the opinions for and gainst the cut-off plan, but I beg of you, as you have the interests of he whole country, not only the overflowed lands along the Mississippi liver, that you investigate the matter closely. The engineers (most of hem) have advocated the notion that the levees would lower the flood urface of the river, but I have insisted that they would raise the "flood urface" in proportion to the water that wasted over the banks that ras confined to the river. I have always believed with the water con-ned to the channel that the gauge reading at Helena should be as reat or greater than Cairo. The gauge at Helena read 42.80 in 1850, hich was the highest water after the cut-off below Friars Point, which ras made in 1848, while the gauge at Helena in 1897 showed 51.85, rith 51.6 at Cairo, and would have been higher had the levees held. This shows an elevation of 9.05 at Helena, caused, as I assert, by the eeves. This elevation would be much greater below here, especially t Laconia and Lake Providence.

Every high water at Cairo since the general levee system was adopted ıas raised the river at Helena until the levees broke. As I said, the ıigh-water mark of 1850 was 42.80 on the Helena gauge. I have not he height at Cairo. In 1858 the gauge at Cairo read 49.60, or 2 feet ıelow 1897; at Helena 44.60, and the levees gave way generally. In 862 the Cairo gauge read 50.80; Helena 46.40, and the levees gone. n 1882 the Cairo gauge read 51.87, at Helena 47.20; 1883 and 1884 were bout the same at Cairo and Helena, as the levees had not been rebuilt. n 1886 the Cairo gauge read 50.98; Helena 48.10, and the levees gone. n 1890 the Cairo gauge read 48.80, Helena 47.70. The levee held in 890, but there was no levee along the White River front, except some 5 miles below Helena. In 1893 Cairo read 49.30, Helena 48. Subse-nent to 1893 the levees were built all the way from Memphis on the ississippi side, and from Helena down on both sides to below Vicks-ırg. In 1897 read on the Cairo gauge 51.60; Helena 51.85, at which age the levees gave way above and below Helena. During the twelve ɔurs from 6 p. m. to 6 a. m., at which time the levees gave way, the se at Helena was 2½ inches, and would probably have continued to se for several days longer. The river at Helena fell 1.35 feet during ıe first twenty-four hours after the levees gave way, and 1.50 during ıe next twenty-four, and continued to fall. The record shows that the ver rose at Helena fifteen days after it came to a stand at Cairo in 93, and only ten days in 1897, and that the rise at Helena for the last ve days in 1893 was 3.35 feet. The most rapid rise was during the

last five days. In 1897 the rapid rise had just commenced at Helena, as the gauge shows a rise of only 0.3 for the 3d of April and 0.35 for the 4th and 0.2 of that during the previous twelve hours. The river would certainly have risen over 1 foot more and possibly 2.

It will be noticed that the building of the levees along the river has been one succession of disaster after another. Each high water has raised the river higher—as high as the levees would hold—and after each high water the levees have been built higher. In 1852 the height adopted was 30 inches above the previous high water, which held until the river at Helena raised 22 inches above 1851. Subsequent to 1858 the levees were built 30 inches above 1858, and held up to the 21½ inches, as shown in 1862. This increased elevation has continued up to the present time, last year's high water raising the river at Helena 3.75 feet above the highest previous mark. And the end is not yet. I claim that the levees will have to be raised from 6 to 8 feet above the present high water below Arkansas River, and Major Starling, engineer for the Lower Yazoo district, said he expected to have to raise his levees at least 6 feet at Greenville.

The advocates for all levees "point with pride" to the fact that in 1897 only about 8 miles of levee gave way. If you will consider the difference in the discharge of the water with the weak levees we had previous to 1897, you will see that 8 miles of breaks would discharge more water than 30 miles in 1880.

In view of these facts, it seems to me that the committee should earnestly seek for a remedy for the present condition of the river, and not let any frivolous objection cause them to discard any plan that may be proposed.

What is needed is some plan to relieve the levees. One plan is outlets. This is to leave openings in the levees where there is no levee along the bank and extend levees on each side of these outlets. This would be too costly, and in addition would be impracticable, as these levees would destroy the drainage of most of the lands, especially the north or higher side of the outlet. An outlet to give much relief should be at or near the head of the basin or swamp. The Yazoo Pass just below Helena is often mentioned as one of these outlets. This would require a levee along the outlet from the Mississippi River to the mouth of the Yazoo, and would destroy the drainage of all the lands from the outlet between the Mississippi and Yazoo rivers. I have long contended that the Yazoo Basin was the only portion of the valley that could be reclaimed by levees. To do this would require the abandonment of the west side from Helena to Red River. It might be possible to levee the river below Red River, if the Atchafalaya was left open, and encourage to enlarge instead of attempts to close it or to prevent its enlargement.

My plan for the relief of the levees is to straighten the river as much as possible from Cairo to the Gulf. I would first make all the cut-offs possible from Cairo to the Gulf. This would leave a succession of short bends in the river of from 4 to 6 miles. Instead of protecting the whole of these bends, I would commence at the head of the bend, where the caving commences, revet the banks—say, from half a mile to 1 mile—and let the balance of the bank cave if it wants to. When the bank below the revetment had caved so that the current did not strike so hard I would revet the next mile, leaving the lower part of the bend without any revetment or protection. This would shorten the river still more. The distance from Cairo to the Gulf could be shortened by cut-off some 170 miles.

One objection to the cut-offs is that they increase the current, cause the banks to cave, and the river soon gets crooked as ever. The survey of the river shows that this is not the fact And when river men have said so I have challenged them to show a single bend that has been formed sufficiently to justify giving it a name since the bends were named seventy or eighty years ago. On the contrary, I claim that the caving is mostly in the bends I propose to cut off, and that in almost every instance where a cut-off has been made a reach or straight place has been made and not only the bend destroyed, but often some other bend has been destroyed.

Take the American Bend cut-off that formed Lake Lee on maps 21 and 22 of the river commission maps. There was a long ugly bend above called Lake Port Bend. This has disappeared entirely. Also on map 20. The cut-off that formed Bulla Lake shows that the river has been shortened since the cut-off made in 1862, and, as Captain Cheek said, "It had made a beautiful piece of river." I would refer now to the river commission report of 1883, pages 281–286, with the accompanying plates. It shows the changes in the river subsequent to the Red River and Raccouci cut offs, which shortened the river some 36 miles, and in the fifty-five years subsequent to the cut-offs the length of the river had been increased some 4 miles.

Another illustration of the effect of increased slope is that the slope of the river from St. Louis to Cairo is 7 inches to the mile, while below Cairo it is only some 4 or 4½ inches. The increase in the slope of the river by all the cut-offs would be less than 1 inch, which would give less current than from St. Louis to Cairo. In fact, the only difficulty I find is that all the cut-offs will not make as great a current as I would like.

So far as caving is concerned, it appears to me that there could not be much objection, as the levees are to be placed so far from the river bank that the caving could at no point reach the levee in twenty or thirty years. But if you will bear in mind that the straight stream will cave less than the crooked one, you will see that objection is answered. There are but few points at which the river has moved east or west even half a mile since the river was known. Of course there would be great caving or washing just after the cut-offs were made, especially if they were all made at the same time or in one year. For instance, take the river from Arkansas River to the Yazoo. The maximum discharge at Hays Landing in 1882 is given at 1,046,000 feet per second, while with the levees up from Memphis down and Arkansas and White rivers high, the discharge at all points below the Arkansas would be at least 2,200,000, or more than double all the way along the Tensas front. It would probably take several years for the river to adjust itself to its changed condition, and those familiar with the river now would scarcely know it after the change.

One damaging effect of the elevation of the river by levees is the effect on the lands near the mouth of the tributaries. Of course no levees could be built to protect these lands, as the levees along their banks above their mouths would prevent their drainage. Great complaint is made already about the backwater at each tributary. Especially is this the case with the White and Arkansas rivers. The levees have already done great damage to the lands along these rivers, and with an elevation of 6 to 8 feet or even more, would do an almost incalculable damage more than now. The cut-offs between Arkansas River and Greenville should lower the water at the Arkansas nearly or quite 10 feet. I do not claim that these cut-offs would lower the river

10 feet below the late rise, which I said above would have been so 6 to 8 feet higher had the levees held.

In connection with the cut-offs, I would call your attention to t report of the River Commission for 1880, Forty-sixth Congress, seco session (Edon 58) page 7, the majority says: "The surface slope m also be increased * * * by cut-offs and other causes." But t majority reject cut-offs. In the same report (p. 22) a minority report given, signed by Major Comstock and Gen. Benjamin Harrison, which they say:

> A reduction of the flood level is very desirable, but where on other rivers this l been effected, cut-offs have usually played an essential part. For this reason are not prepared to absolutely reject their use.

It will then be seen there are other advocates for cut-offs besides m

In looking over the river commission maps I find there are 26 plac at which cut-offs could be made. Of these about 16 are such as cou be made at but little cost or time. They could be made in one seas as well as twenty, and the relief would be more immediate. The di tance across these necks or narrow places is from one to three mil except one of five miles. The cost would be in digging a ditch or can across these necks. Some would require large and some small ditch But none of them would cost more than many of our large leve according to length—that is, dirt necessary to build a levee would ma a ditch large enough to make a cut-off. The ditch or canal should dug so as to turn the current of the river above as directly as possib into the channel or current below. About all the cut-offs have be made where the neck was narrowest. This, in most instances, h thrown the current against the bank on the opposite side so as to cau great destruction.

Accompanying this I send a sketch of plates 20 and 21, taken fro Captain Ockerson's maps "of the Mississippi River from St. Louis the Gulf." I have marked the cut-offs I would make on this part of t river, and you will see it would make the river so nearly straight th there would be no bend left worthy of a name.

I would impress on your minds that I do not propose to do away wi the levees, as they would reclaim a large portion of the country, esp cially at the head of these swamps or basins, but that they would so large as to cause great destruction when they break and wou require the cut-offs to relieve them of their extra height. In some po tions of the river they could give no relief, because there are no bend below to cut off—as below Bayou Goula, 200 miles above the Gu New Orleans would have to hold all the water, about 2,400,000 cub feet, except what would pass out at the Atchafalaya.

I beg of you again to consider this matter well, and get the opinio of such men as General Comstock, General Harrison, and Captain Fla of the River Commission. I would also suggest, in view of the doub about the effects of the levees and cut-offs, that the Government sele some section or district along the river and try the effect of both ide The district should be the one least affected by tributaries. I wou suggest from the St. Francis to White River, as there would be little no complication from tributaries.

There are one or two bends in this section (on plates 18 and 19) th could be made without much interference with the rest of the riv One is what is known as the bend of 66, from Offuts Landing to Lo lows, on map 18. The other is on page 19, from Ellisons to McGh Landing. The two on page 20 might also be made. If the Gover ment should take charge of the levees or river and put the work in t

hands of one man like General Comstock, or a commission that does not believe they can put a quart of water in a pint cup and also believe a straight ditch drains better than a crooked one, I think we may hope to see the river controlled some day.

All of which is most respectfully submitted.

JAMES B. MILES.

P. S.—I have included plates 20 and 21 on the same sheet.

J. B. M.

ON BOARD STEAMER MISSISSIPPI,
February 4, 1898.

C. H. PURVIS, sworn, testified as follows:

Examined by Mr. NELSON:

Q. Please state to the committee what position you occupy?—A. I am chief engineer of the Cotton Belt Levees.

Q. What is known as the White River front?—A. Yes, sir.

Q. Are you under the State authority or under Federal authority?—A. A little under both. I am an assistant engineer in the Government service.

Q. And you have charge of the White River Basin as the State engineer?—A. Yes, sir.

Q. What is the extent of your levee line?—A. Sixty-eight miles—from Helena to a little below Henrico.

Q. That does not include the whole White River Basin?—A. Yes, sir; that includes the whole White River Basin.

Q. How long have you had charge of this district?—A. Since 1887.

Q. Do you know how much has been expended on that levee by local and Federal authority, and what proportion by each?—A. I think there has been about $900,000 expended by the Federal authorities and between $300,000 and $400,000 (I do not remember exactly) by the State authorities—I think about $370,000. There was, before there was any organization at all, a considerable amount of old levee contructed by private individuals and by the State.

Q. Has that been incorporated and utilized as a part of your system?—A. Yes, sir.

Q. When was most of your levee work done?—A. Most of it has been done since 1890.

Q. What is the area of land protected by this levee, assuming you are not exposed from above?—A. The area of land protected by this levee is about 583,000 acres, as I remember it now, on the east side of White River. There is some land west of White River which is protected by the levees of the White River front. It also protects a portion along the Arkansas River. There are some channels across the delta between the Arkansas and White rivers, through which overflow water gets into the Arkansas River and increases the flood height against the levees on the Arkansas River in the neighborhood of Possom Fork Levee. They had no water this last year until these levees broke here, so they tell me.

Q. What is the average height of your levee now?—A. The average height is about 12 feet.

Q. Above the ground?—A. Above the ground; yes, sir.

Q. How was that levee affected by the flood of 1897?—A. It was practically overtopped from one end to the other.

Q. It is too low, then, for such a flood as that?—A. Yes, sir.

Q. How did the flood of 1897 compare with prior floods within your recollection opposite your levee basin?—A. It was very much higher.

Q. How much?—A. It is about 4 feet higher here, and along the center of this basin nearly 6 feet higher.

Q. From 4 to 6 feet higher?—A. Yes, sir.

Q. Up at Cairo it was not quite as high as in the 1882 and 1883 floods?—A. No, sir.

Q. How do you account for the great increase in height here in the flood of 1897 as compared with the prior floods? To what causes do you ascribe it?—A. I attribute it to two causes—one the prolongation of the flood height at Cairo, its extreme duration; the other cause is attributable to the construction of levees.

Q. To the construction of levees above here?—A. No, sir; to the construction of levees here.

Q. Penning up the river here?—A. Yes, sir.

Q. And on the other side?—A. And on the other side.

Q. If your levee system is completed you will need a great deal higher levee, will you not?—A. Yes, sir.

Q. About how much higher?—A. I think an average of 6 feet higher would make it ample.

Q. That would make about an 18-foot levee?—A. About an 18-foot levee; yes, sir. I think that would be ample for any flood that we will ever have.

Q. You heard Mr. Miles's testimony, where he said that he thought straightening the bends of the river, making cut-offs, would relieve the river somewhat from the effects of floods. What are your views on that subject?—A. I think that it would probably give relief immediately above the cut-off, but I think it would undoubtedly increase the flood height very materially below. In proportion as you would relieve it above, you would increase it below. Colonel Miles has discussed that point somewhat with me. He looks at the map where these old cut-offs are shown to have occurred, and sees that that particular reach of the river is straight or comparatively straight right where the cut-off was made. But the bends immediately below and above have increased. The old bends have cut in and the river has, within a radius of 120 miles, or something like that, regained all the length which it lost in making the cut-off.

Q. And diminishing the channel lengthwise is as bad as diminishing it crosswise?—A. Yes, sir.

Q. And will have the same effect in increasing the height of the water below?—A. Yes, sir. Colonel Miles testified about the levees raising the water 9 feet or more since the levees were first constructed.

Q. Since 1851, I think?—A. Yes, since 1851. Well, the country overflowed before that. He says that we have the extreme high-water mark now. Well, there is from 2 to 6 feet of water against the levees of the White River front to-night, and the bank of the river, or the ground on which those levees are placed, is the highest ground in this delta, still the river will overflow without any levees and inundate all the country. Now, of course, there is an overplus which we can confine, as I said. We raise the water somewhat by confining it with the levees, but there is a limit to the height that we will have to build them, and the levees act on the river simply as its own or natural bank does; they would have the same effect (after we built these levees) on the river as the natural bank of the river has. They produce no change at all. And this limit I think we have nearly reached in the construction of the levees. Of course as we raise the levees higher it takes a great

eal more dirt to build them, and it would probably require about a illion dollars to make this stretch of levee along the White River asin absolutely secure against flood.

Q. And you have expended now about how much?—A. Somewhere ear $1,200,000 or $1,300,000.

Q. And a little more than one-third of that has been paid by the local uthorities?—A. Yes, sir. Well, as I say, there was some old levee in here before. I do not know how much that was. It would take now bout $1,000,000 to complete it and make this reach of the river absoutely secure. I do not think it would require a cent more.

Q. That is always on the assumption that the river is properly leveed above?—A. Yes, sir.

Q. And that you are not subjected to any crevasses above?—A. Yes, sir. My opinion is that we ought to be leveed from Cairo to the Gulf.

Q. Is your levee on this front constructed in such a manner back from the river and from the bends that it is likely to be fairly permanent?—A. In almost every instance. There is only about 2 miles of it that I do not consider permanent levee.

Q. Who fixed the location of this levee; the Federal engineers?—A. Yes, sir; most of it.

Q. They have laid it out?—A. Yes, sir.

Q. It is on their line of work?—A. Yes, sir.

Mr. GALLINGER. You say that the Government laid out the levee. Now, was that a matter of suggestion or of requirement on the part of he Government engineers?

A. Where the Government built it laid its line out, and very frequently, where the lines would connect, they would suggest. There was othing compulsory in the matter whatever.

Mr. NELSON. But practically their suggestion was followed?

The WITNESS. Their suggestion was followed; yes, sir.

Examined by Mr. BERRY:

Q. Major, it has been urged that the closing of the St. Francis Basin ould endanger the line below. Others have urged that the water was s high at Helena during the flood of 1897 as it would have been had ll the basin been closed before the flood. I want to get your views in egard to that matter, and also as to what effect the closing of the azoo Basin has had upon the river, and what you think would be the ffect if the St. Francis Basin were closed. Now, you understand what want you to testify about—in regard to the St. Francis Basin, its effect pon the river, upon the high water at Helena, and what effect it would robably have now upon the Mississippi side of the river if the basin as inclosed, or on the White River front, or anywhere else.—A. My pinion is that the closure of the St. Francis Basin would benefit all of e levees below here. I base that opinion largely upon the effect of e closure of the White River Basin. When the river reached the revious high-water mark last year (48 feet) the levees of the White iver front and of the Yazoo Basin were intact; and at the lower end f the White River Basin we had lower water than we had ever had ith a similar height above and a similar height at this point. When he levees broke and flooded the White River Basin and that water was arried to the lower end by two routes, then we began to feel this xtraordinary high water down there. But up to that time the water as lower from the place called "Wood Cottage" (about 12 miles above Henrico). From there down there was a very rapid slope in the flood lanes, and the water from there down was below high water. On the ay that the river lacked 4 feet of overtopping the levee at Wood Cot-

tage I drove in a buggy on dry land outside of the levee at Henrico, 12 miles below. The levees were built on the old grade line, 3 feet above high water. Now, with the White River front as a precedent as to the effect of these levees, I think the same effect would be felt by the closure of the St. Francis Basin, and that we would not have as high water here as we would have with the basin opened and the water coming by two routes.

Q. You think that the flood coming down in the main channel and joining that which came out of the St. Francis Basin made it higher at Helena than it would have been if the water had all come down the main channel?—A. Yes, sir.

Q. You think the river was higher by reason of the water joining 8 miles above with that which came out of the St. Francis River?—A. Yes, sir. There are occasions, and it has generally happened, that that would not be the effect. This year the water was flowing into the St. Francis Basin (and the same thing occurred in 1882), and the water stayed high at Cairo for so long a period of time that we got no fall in the river here at all before we got this water from the St. Francis. Now, usually it has been the case that before the St. Francis water comes out here we have had some fall in the river. When the river begins falling at Cairo it takes about fourteen days for the water to get around through that basin and come down here.

Mr. NELSON. And four by the river?

A. Yes, sir. It was at extreme height above the danger line at Cairo about eighteen days in 1897, if I remember right, and the river was still rising here from the water in the main channel when the St. Francis water began to pour out on us. And in that way I think we undoubtedly got an increased height of water here this year, from the fact that the St. Francis Basin was open. That water coming through the basin, striking trees and other obstructions, accumulates; and it crosses the water in the Mississippi River down here. The current sometimes runs directly across it, comes out of the St. Francis, and impinges directly on the Mississippi levees; and when there has been a considerable fall in the Mississippi River I have seen the water flowing 3 or 4 feet over the banks of the Mississippi into the Mississippi from the St. Francis.

Q. Do you think it is a certainty that if the levees were made, say, 18 or 20 feet high, closing the entire river from Cairo to the Gulf, it would hold any flood waters we have ever had in the past, if the levees were properly constructed all along the line and, say, from 18 to 20 feet high? Do you think that would absolutely hold (provided no accident happened to the levees) any flood that we have ever had in the past?—A. Yes, sir.

Q. You do not think there is any doubt of that fact, do you?—A. No, sir; none at all. There are some places (where you cross old river beds and things of that kind, where there is no external evidence of anything unusual) that we might strike a bad foundation for the levee, which would cause a break; but if there was any evidence of that visible during the construction the levees could be so constructed that there would be absolutely no danger of a break.

Q. If I understand you, then, from your observations of the White River front, you are of the opinion that if the St. Francis Basin should be closed the levees below would not be subject to any greater strain than they would be with the basin open?—A. No, sir. They would, in my opinion, be subjected to a lesser strain.

Q. Is it the general opinion of the people along the Mississippi River

that it is better for the Government to have the whole matter in ge and under its control?—A. Yes, sir.

You think that represents the general sentiment of the people g the valley, so far as your knowledge extends?—A. Yes, sir; so s I have heard at all. I have not heard a dissenting voice. The le feel that the Government has greater power and better facilities aintain, construct, and control levees in the proper places, and that uld be better in every way.

We are also instructed to investigate the question of the outlet m and the reservoir system, whether or not reservoirs can be con- ted either at the head waters or in the St. Francis Basin or any- e else which would have the effect of diminishing the floods. t do you think about that?—A. I do not think it is possible to truct a reservoir much larger than the entire Mississippi Valley, that has been full of water as well as the river; so I don't think eservoir plan is a very practical one.

You do not think that any reservoir could be constructed in the rancis Basin, at any reasonable cost, that would have any appre- e effect on the water below?—A. No, sir.

What do you think about Captain Cowden's outlet theories?—A. ieve that the character of the river is such that if you were to the Mississippi River off at Lake Borgne, chop the earth right off , that we would still have high water here; that the outlet system tirely impracticable, because we could not get the water to the t.

It would not be possible to construct an outlet anywhere in the ity between here and Vicksburg, or above the mouth of the Red r, that would carry it to the Gulf anyway, would it?—A. No, sir; not think it would, from any knowledge I have of that country.

And the diverting of it at Lake Borgne you do not think would any effect on the flood level up as high as Vicksburg and between and there?—A. No, sir.

Examined by Mr. NELSON:

Why do you want your levee 6 feet higher than it is now? What e basis of your claim for that extra height of 6 feet?—A. Well, the rose here some 4 feet after the breaks in the White River front, I think it would have risen that much there, and there ought to be factor of safety. Evidently we have not them high enough now.

If you had had such levees in 1882 as you have now they would been high enough, would they not, at the gauge reading you then —A. At the gauge reading we had then, yes, sir; but I do not if we had had the levees that we would have had those gauge ngs. If we had had the levees we would have had a higher gauge 82 than we had.

If I understand the drift of your testimony, then, so far as your front is concerned, it would not make any difference to you if they ld proceed at once to close up entirely the St. Francis Basin?—A. ir.

It would not affect you in any way?—A. No, sir; I do not think uld.

And if that theory is correct they might do it before you had ased the height of your levee above its present height?—A. sir.

It would not put you in any worse condition?—A. No, sir.

Q. If the entire basin was closed you would not be in a worse condition than you are now with your levee as it is?—A. No, sir.

Q. And you would have no objection to the closing of the basin?—A. No objection in the world.

Examined by Mr. CATCHINGS:

Q. In your judgment, is there any other means of protecting the alluvial lands of the Lower Mississippi from overflow except by means of levees?—A. I do not think there is. I think that the levee system is the only practical method of giving protection.

Q. You are familiar, of course, as an engineer, with all discussions that have taken place on the subject of outlets?—A. Yes, sir.

Q. You regard them as impracticable and valueless?—A. Yes, sir.

Examined by Mr. GALLINGER:

Q. Major, I suppose you have heard freely discussed among your people the question of the proposed guardianship or proprietorship of the levee system on the part of the Government, and continued contributions of the citizens to a fund designed to build these levees?—A. Yes, sir.

Q. Have you heard any suggestion made by any of your people—lawyers, for instance—as to how that partnership could be effected so as to protect the Government? In other words, if the Government took possession of, and in its sovereign capacity became responsible for, the building of these levees and engaged in a comprehensive system of building, have you heard it discussed as to how the Government could be protected? A gentleman to-night said that the municipalities or the districts of the State would continue to contribute. Do you know of any way in which the Government could enforce contributions under those circumstances?—A. I do not.

Q. Have you any knowledge of any claims to amount to anything against the Government for damages because of the levees already built?—A. No, sir.

Q. You have heard it suggested that there are such claims pending, have you not?—A. No, sir; I have not.

Mr. STARLING. About Natchez?

The WITNESS. I never heard of it. The only suggestion I have heard of that kind was one that came from the people on Indian Bay, who imagined that the construction of the levees on the White River front were injuring them, and they talked at one time of bringing some sort of a suit against the Government for damages. But the first high water after the White River front was closed so thoroughly convinced them that the levees were their only safeguard that they are the most enthusiastic levee people that we have now in the whole country; they are the people living on White River, about fifty miles west of here.

Colonel GILLESPIE was then examined, as follows:

By Mr. GALLINGER:

Q. I will ask, Colonel, with respect to whether there are any claims that you have any knowledge of pending against the Government for damages because of the building of levees by the Government?—A. There was a series of claims made below Vicksburg last year. I do not remember the number, nor do I remember the aggregate amount of the claims. My impression is there were five claims. They were turned over to the district engineer, Captain Dabney, who examined them, and they were returned through my office to the Court of Claims, from which they emanated. Lately five claims have passed through

my office; one, and possibly two, emanating from the lower Yazoo, one from the Homochito, probably two. I don't remember where the fifth claim came from. I think the aggregate of the five claims this year is in the vicinity of $300,000. One claim alone was two hundred and twenty-odd thousand dollars, I think.

Mr. CATCHINGS. Who made that large claim—do you remember?

A. I do not remember. Those claims were referred to the Court of Claims, from there to the Secretary of War, and through the Chief of Engineers to the present Mississippi River Commission for report. Having no details, they were transmitted to local officers of engineers serving under the Mississippi River Commission for examination and report.

The witness PURVIS was then examined, as follows:

The WITNESS. As to your legal question, I noticed the other day (I expect Major Starling knows more about it than I do) that there is a constitutional amendment now being submitted to the people of the State of Mississippi for authority to make this transfer, and, I suppose, to prepare laws which would cover it. I suppose it could be arranged in some way that would protect the Government along lines of that kind.

Mr. NELSON. Are these claims for right of way and for pits where you get the earth?

A. Claims of that kind in this district, and, so far as I know, in others, have been settled directly by local authorities.

Mr. NELSON. Or are they claims for damages on account of being left outside of the levees built?

Mr. STARLING. It is for the raising of the high-water line. All claims for right of way are settled by the local authorities.

Mr. NELSON. They are simply claims on the ground that by raising the river you flooded their lands?

Mr. STARLING. Yes.

ON BOARD STEAMER MISSISSIPPI,
ABOVE ARKANSAS CITY, *February 5, 1898.*

T. G. DABNEY, sworn, testified as follows:

Examined by Mr. NELSON:

Q. Major, you are the engineer in charge of the Upper Yazoo district?—A. Yes, sir.

Q. Are you the Federal engineer or the local engineer?—A. I am the local engineer.

Q. Under the State authorities of Mississippi?—A. Yes, sir.

Q. How long have you occupied that position?—A. Fourteen years next May.

Q. Please state the boundaries of your levee district.—A. The levee district consists of nine counties, in whole and in part. Five of those counties are entire and the other four are fractional parts.

Q. From what point to what point along the river does your district extend?—A. From the northern line of the State of Mississippi to the northern line of Bolivar County, Miss.

Q. That is a little above the White River?—A. Yes, sir.

Q. Where do you commence the levees in the Yazoo Basin?—A. At the hills very near the north line of the State.

Q. How far below Memphis?—A. By rail, about 13 miles.

Q. What is the levee front of your district—how many miles in length?—A. The linear extent of the levee lines in my district is 123.81 miles.

Q. That represents your levee mileage?—A. Yes, sir. I should modify my statement of the mileage in the front of my district by saying that that does not truly represent the frontage. We have some complications which it would take some little time to explain. There is a lapping of one line over another.

Q. I was simply trying to get generally at the mileage of the front.—A. It is about 108 miles.

Mr. CATCHINGS. And about 123 miles of levee?

The WITNESS. Yes, sir.

Q. My recollection of Major Starling's frontage is that it was about 216 miles. Your district is, comparatively speaking, as regards his district, the younger and later district, is it not?—A. Yes, sir. The present organization is much younger than that which exists in his district.

Q. When did levee construction begin in your district?—A. During the seventies there was an organization formed.

Q. A local organization?—A. A local organization. And I do not remember how or why or when that went to pieces, but at all events, for a period of five or six years prior to the present organization there had been none at all.

Q. When was the present organization begun?—A. In 1884, by an act of the Mississippi legislature, approved February 8, 1884, as I now recall.

Q. Then you trace your present system of levee construction practically from that time, do you not?—A. Yes, sir.

Q. Before that there was no cohesion to it and no systematic improvement?—A. Well, at that time I first became acquainted with this levee district, and I made surveys and——

Q. What was the condition of the levees at that time, when you became acquainted with them—that was in 1884?—A. The levee lines were very imperfect in all respects, both in dimensions and height, and the three preceding high waters of 1882, 1883, and 1884 had broken through the levees in a multitude of places. As I now remember, there were some 39 miles of actual openings in the levees.

Q. Crevasses?—A. Yes. And in many other places the water had washed over and partly washed it away.

Q. What was the average height of those old levees above the ground?—A. I will have to make a guess at that. I should say 8 or 9 feet.

Q. Will you go on and state briefly the levee construction that has been carried on since 1884?—A. Yes, sir. The legislature authorized this levee district in 1884 to issue bonds to the amount of $500,000. They were issued and were floated at par, and the proceeds of those bonds were expended during 1884 and 1885 in repairing the breaks in the levee line and in strengthening the weaker parts. The amount was entirely insufficient—was less than half enough to build to the standards then adopted.

Q. You adopted a higher standard then?—A. Yes, sir.

Q. How much higher than existing levees?—A. I should say about 3½ feet higher.

Q. That would give you about a 12-foot levee?—A. Yes, sir. The standard adopted was 3 feet above the high water of 1882, and, as I now remember, the result of my investigations was that the general line of that levee was half a foot below the high water of 1882.

). And your idea, then, was to make your levee 3 feet higher than guage of 1882?—A. Yes, sir.

). And you proceeded on that theory?—A. Yes, sir. We were not to accomplish that by the means then in hand, but we made it go ar as possible toward the restoration of the general line. In 1886 legislature authorized a further issue of $400,000 of bonds. Bonds e issued, and a fund realized and also expended in furtherance of object of bringing the levees up to that standard.

. In the meantime, while you were expending the proceeds of these issues of bonds, were you getting any Federal help?—A. Not at t time. The maintenance of the lower 12 miles of the levees of district at that time had been assumed by the lower-levee district, their own protection. When no organization existed above them, extended their system 12 miles up from Bolivar into Coahoma nty, so that our first efforts were exclusive of that part of the line—he lower 12 miles; our efforts were confined to the portion of the above that point. In other words, that was not embraced in our mate of cost.

). Since you issued those bonds, what further sums, if any, has the rict expended in levee improvements? Give us all the bond issues the cash that you have raised.—A. To complete the subject of the d issue, in 1887 the legislature anthorized a further issue of $500,000.

). That made the third issue?—A. That made the third issue; mak-, altogether, $1,400,000—two $500,000 issues and one $400,000 issue. proceeds of that last issue constitute a fund that is now being ended on our present work. Here is a compendium, made to June 895, of all the work done and expenditures made.

). Will you please give the aggregate of the expenditures?—A. I l read the items which it embraces. Construction, 7,124,615 cubic ds; cost, $1,564,376.17; bank protection, $42,653.77; drainage nals, culverts, siphons, etc.), $14,985.29; right of way and dam-, $82,107.78; high-water expenses, $62,505.84; levee maintenance, ,344.29.

). What do you embrace in that item of levee maintenance?—A. inly it consists of the operations of a hired repair force, that is main-ied all the time to repair damages from wave wash and rain wash, l defects of that kind, and occasionally to do some construction work.

). You do not include in that what would be termed the general and manent maintenance of the levee, then?—A. No, sir; this is mainly porary work, but some work where it has been specially needed. ephone construction, $2,206.59; engineering expenses, $129,032.98; aries (that is, the president's salary, treasurer, auditor), mileage, and diem, $47,476.19. That includes mileage and per diem of the mem-s of the levee board when they attend meetings. Attorney's fees, 513.03; genera expenses (miscellaneous), $29,476.93. That is for office niture, stationery, and things of that kind. Express, exchange, and missions on the sale of bonds, $21,074.34; interest and coupons, 5,882.17; sinking fund, $175,000; total, $2,806,630.37. Work done the United States to June 1, 1895, 3,265,046 cubic yards. Appro-itions to pay for same, $628,600.

have a footnote here saying, "Since the above statement was com-d an additional sum of $50,000 has been invested in levee-board ds for sinking fund, making the aggregate so invested amount to 5,000 to this date—October 1, 1895."

. What is the aggregate, then, of the amount expended by your rict in improvements, up to the present time, as near as you can

give it?—A. I will say by way of explanation that in addition to the bond issues or the money realized by them we have expended every year about $100,000 from the surplus of the fund derived from taxation.

Q. You have a regular tax every year for levee purposes?—A. Yes, sir.

Q. What is the rate of that taxation?—A. At present, on the three front counties, it is 17½ mills ad valorem, with the addition of a specific acreage tax of 5 cents per acre. On the rear counties (those that are back from the front) the ad valorem tax is 12½ mills and 5 cents per acre acreage tax. That is the maximum tax allowed by the legislature. The levee board is invested with authority to diminish that tax when they see proper, but they can not exceed it.

Q. Taking the proceeds of the bonds and what you have collected by taxation in this way, what is the aggregate amount, as near as you can give it, that has been expended by your district?

Mr. CATCHINGS. You might include in your answer all the money you propose to expend this year; count that as expended.

A. Should I include high-water expenses? That is about $200,000.

Q. Yes; I want what you have expended for levee purposes.—A. Well, in a round sum, $3,588.000.

Q. That has been expended by your levee district for levee purposes?—A. Yes, sir.

Q. What has the Federal Government expended in your district? Give it in the same way that you have given the State expenditures.—A. I am not absolutely certain of correctness, but I think about $732,000.

Q. I wish you would be kind enough, at your leisure, to prepare a statement of the total amount expended by your district, and the amount expended by the Federal Government in your district, and send it to me.—A. I will do so. What I have given represents, I am quite sure, practically the relative amounts expended by each, but I will give you an accurate statement of it later.

Q. You say that in 1884 or 1885 you started in on the theory that you wanted to raise your levees about 3 feet above the high water level of 1882?—A. Yes. That was the highest water that we had then had.

Q. Did you raise them to that extent?—A. Yes, sir.

Q. How long before the flood of 1897 had you got your levees completed to the height of 3 feet above the old basis?—A. About 1890.

Q. About in 1890, then, you got your levees completed up to the standard that you fixed after the flood of 1882?—A. Yes, sir.

Q. The new grade that you adopted in 1884, of 3 feet higher, you had substantially completed in 1890, say?—A. Yes, sir.

Q. The grade established in 1884 and completed in 1890 gave you substantially a levee of between 11 and 12 feet in height; that is correct, is it not?—A. I think that is correct.

Q. About when, and to what extent, did you change that grade?—A. After the standard of 1884 had been established and completed it was found that the high waters thereafter were not parallel with the high water plane of 1882, but there were local differences. In some places it was considerably higher than others, relatively to 1882, necessitating a modification of the grade lines as these developments occurred. The 1884 grade line was maintained for a longer time in the upper part of the district than in the lower part. In 1891 I find this observation: The grades from Austin, as far down as Thompson's, are 3 to 4 feet above high water. Austin is on the forty-third mile and Thompson's is on the sixtieth mile.

Q. What was your average standard immediately prior to the flood

f1897?—A. For the upper 43 miles it was 5 feet above the high water f1882.

Q. That would make it 2 feet beyond the 1884 new grade?—A. Yes, r. And from that point down it was 4 feet above the highest water. he highest water varied in different localities from there down.

Q. How much, on an average, would it be higher than the grade of 94? Two to three feet?—A. Yes, sir; it would be quite 2 feet higher an the grade of 1884.

Q. You can summarize it, then, by saying that subsequently to the rfection of your standard of 1884 you increased your standard subntially from 2 to 3 feet along your line above that standard?—A. iat is up to 1896?

Q. Yes, sir.—A. Well, I will say an average of about 2 feet above at of 1884.

Q. That was prior to 1897?—A. Yes, sir.

Q. So your standard grade of levee immediately prior to the flood of 97 was between 13 and 14 feet?—A. Yes, sir.

Q. What causes induced or necessitated you to increase your grade 1884?—A. Because of the extensions of the levee lines on both sides the river, so as to exclude the escape of the water into reservoir sins that before that time it had access to.

Q. The reason, then, substantially was this: That the increased height is superinduced by the continued construction of levees above and e closure of river basins?—A. Yes, sir; by the extension of levee ies and the further confinement of the floods to the channel of the ver.

Q. Yes; the further inclosure of river basins.—A. Yes, sir.

Q. And in your experience the tendency has been that as the levee stem progressed and was perfected it increased the high-water level the river and necessitated higher levees?—A. Yes, sir.

Q. Had you got that standard perfected fairly well, of from 13 to 14 et, prior to the flood of 1897?—A. Yes, sir.

Q. That flood demonstrated to you that that standard was insuffient, didn't it?—A. Yes, sir.

Q. By how much in height?—A. I should say an average of 4 feet.

Q. Demonstrated that it would be necessary to go 4 feet beyond the to 14 feet standard?—A. Yes, sir.

Q. Making from 17 to 18 feet?—A. Yes, sir.

Q. Taking Cairo as a basis, the high-water gauge of 1882 and 1883 is higher than any since?—A. Practically the same as 1897.

Q. In 1883 it was a little higher?—A. A little higher; and in 1884, believe, a little lower.

Q. And in 1882 pretty much the same?—A. Pretty much the same. iere was very little variation in those four years at Cairo.

Q. Well, the fact that the gauge of 1897 was not any higher at least an at those earlier floods would indicate that the great increase in e height of the water opposite your levee arose not from increased ter, but from increased building of levees and closure of levee sins?—A. Yes, sir; there is no doubt about that fact.

Q. What effect has this closure of the river basins and the building these levees had upon the channel of the river? As you have narved the river within those levee lines, and the river level has gone , what has been the effect as to the bottom of the river? Has it reased in height or has it maintained itself, or has it cut down eper, in your opinion?—A. I can give you my opinion. I have no curate information on that question.

Q. It is your opinion that we would like to have?—A. My opinion is that sufficient time has not yet elapsed to develop any marked effects.

Q. Do you think there has been any building up of the bottom of the river in the main channel?—A. I feel quite certain that there has not been.

Q. Do you think there has been any material deepening?—A. I think it is not probable that there has been within the time that has elapsed since this water has been thus confined in places where it had not been confined before.

Q. What, in your judgment, ought to be the standard of the levee for the future to afford you ample protection, bearing in mind that all of the basins above Cairo be closed up and leveed, so as to keep the water back and the river confined within the levees from Cairo down? How high a levee would you need then, in your opinion?—A. You have reference to my particular frontage?

Q. Yes, sir.—A. It is not possible to determine in advance just what the elevation of the high-water plane is going to be, with the levees constructed all the way so as to prevent the escape of any water.

Q. But you have no doubt but what such a leveeing would materially increase the high-water level?—A. I think it would. And now, with the experience of last year, when there was a very much nearer approach than ever before to a complete leveeing of the river, we are enabled to arrive with more confidence at an approximate estimate of what our ultimate needs will be. I have formed some conclusions on that subject.

Q. I wish you would give us those conclusions.—A. I will say that it is my conclusion that my present line of levee will have to go an average of 5 feet higher than it is now, in order to be able to resist the highest water that we may anticipate in the future from a complete leveeing of the entire river.

Q. And how high would that make it?—A. I have never considered the subject in this aspect, as to the average height of the levees.

Q. Well, you were left prior to 1896 with between 13 and 14 feet. Would you want 4 feet above that?—A. Yes, sir.

Q. You would want about 18 feet, then?—A. To make a perfect levee; yes, sir.

Mr. VEST. What would that average make the width of the levee at the base?

The WITNESS. The average width?

Mr. VEST. Yes.

The WITNESS. That would make 104½ feet, according to the height and according to my cross-section dimensions; 104½ feet, and behind that a banquette 40 feet wide, which would increase the width to 144½ feet.

Q. Is that banquette continuous or only in spots?—A. it applies to levees above a certain vertical height. Wherever the levee exceeds 10 feet in height there is a banquette.

Q. Your levee slope is one on three generally, is it not?—A. My standard is one on four on the land side and one on three on the river side.

Q. And the crown is 8 feet?—A. My standard is 10 feet.

Mr. CATCHINGS. Explain what you mean by a banquette, how it is constructed, and its height as compared with the height of the levee.

The WITNESS. Banquette is a French word that means bench. I ought to have said bench in plain English.

Q. It is to fortify the levee in the rear?—A. Yes.

Mr. VEST. It is a basic fortification.

Q. Now, have you any idea, or will you give us your best views as to

hat would be the approximate cost of completing your levee up to the ew standard of 18 feet?—A. In round numbers, about $2,000,000.

Q. It would take about $2,000,000 to perfect your system?—A. Yes, ir; that, in view of the fact that the work is becoming more costly all he time as it progresses; material has to be transported farther and arried up higher, and it makes the cost per cubic yard greater.

Q. What is the average cost per cubic yard now for building your evees?—A. This season's work, to speak somewhat loosely, averaged bout 15 cents, possibly 16 cents.

Q. There was a gentleman here from Helena last night who called ur attention to an idea he had. He thought that, in addition to the evee system, it would help a great deal in relieving against floods to ake cut-offs in these bends, shorten the river, cut off the bends, and traighten the channel. What are your views on that subject?—A. Vell, to put it with as much emphasis and brevity as possible, in the anguage of the medical profession, it is "contra indicatived."

Q. Your idea, I take it, then, is that the chief mode in which the oods can be repressed and the country protected from overflows is by eans of the levee system?—A. I consider that the perfection of the evee system is an absolute necessity for the protection of the alluvial nds from overflow.

Q. Would you supplement it with anything else?—A. I would supplement it, yes, sir; but the supplement would be the chief feature in e end; that is, give absolute stability to the banks of the river.

Q. By revetment work?—A. Yes, sir.

Q. That would be at the bends?—A. Yes, sir.

Q. At the bends that are subject to undermining. Is there any work esides revetment that you would have supplementary of the levee system to protect against floods?—A. That is the only work that I can see s necessary to accomplish that end.

Q. Could anything be done in the way of protection by the construction of reservoirs anywhere? Would it be practical to construct reservoirs at reasonable cost?—A. In my opinion, it is entirely impracticable. will make this suggestion, by way of emphasizing my view, that you would have to cover more surface with your reservoirs than you would rotect from overflow, because your reservoirs would contain still water; our protected area has water all the time moving on. It would require eservoirs so capacious as to be beyond the field of consideration to estrain enough water to afford any relief at all.

Q. In other words, an artificial reservoir entirely closed up would equire to be larger than a natural reservoir open?—A. I presume I ight say, just by way of illustration, that you would have to convert he whole State of Wisconsin into a reservoir in order to protect the lluvial lands of the Mississippi River.

Q. Now, you know something of the so-called outlet system?—A. es, sir.

Q. In your opinion, could any relief against floods be obtained by eans of the outlet system?—A. None at all, sir, in my opinion.

Q. At all events, not above the mouth of the Red River, could ere?—A. There could not be an outlet made above the mouth of the ed River, properly so called.

Q. And if outlets were made below, in the nature of the case, even they gave relief below, they could not afford any material relief to e country above?—A. None whatever.

Q. Except for a short space above the outlet?—A. Exactly; and that a temporary nature.

Q. And the only relief they could possibly afford would be by producing a little more rapid current and a little more scour, perhaps, above?—A. Their influence would extend to a very limited distance above, and would be temporary in its character.

Q. So that, in the country above the mouth of the Red River, they could not, by any possibility, cut any figure at all?—A. Not in my opinion.

Q. First, because no outlets could well be constructed, and outlets below that point could not afford any relief to the country above?—A. Well, above the mouth of the Red River there is a series of basins and subbasins. Now, to make an outlet into any one of those basins would simply be like pouring water into a jug—simply fill up the basin, and then it would have to return to the river.

Examined by Mr. CATCHINGS:

Q. What you mean by a real outlet is one where the water goes out and never returns?—A. Exactly; where it is conveyed away entirely and never returns to the river.

Q. Do you remember the case of the Nita Crevasse?—A. Yes, sir.

Q. It was stated by Captain Kingman at that time (the officer in charge of that section of the country) that actual measurements showed that 400,000 cubic feet per second went out through that crevasse and that water never returned. That was a real outlet, was it not?—A. Yes, sir.

Q. As I recollect his statement, there was no appreciable effect from that outlet, 60 miles above.—A. That is my recollection of it.

Q. There was a fall of a foot and a half at New Orleans below, but 50 or 60 miles above there was no effect at all. That would be an illustration of what an outlet of that size will do?—A. I think so.

Q. And he stated, also, that the discharge through the Nita Crevasse was about one-third of all the water passing through the river?—A. Yes, sir. There is another feature about that, a very important one, and that is that the channel below the outlet would deteriorate.

Mr. NELSON. The carrying capacity would diminish?

The WITNESS. Yes, sir.

Mr. NELSON. If you divided the current of the stream into two or three subsidiary currents the tendency would be to diminish the flow?

A. Exactly; diminish the capacity of the channels.

Examined by Mr. VEST:

Q. Do I understand you to mean, when you say that you would use levees and revetments, that you would discard entirely the dredging system and contraction works?—A. Well, I did not conceive, Senator, that that had any connection with the question of overflow. That pertains to the navigation interests.

Q. Well, if you improved the channel so that water would come down the middle of the river more rapidly and in larger volume would not that be something that would diminish the floods?—A. I presume it would, sir, but I do not conceive that dredging low-water channels would have the permanence that would give any such results as that.

Q. Under this resolution we are instructed to examine also as to the effects of different improvements upon navigation. Now, what do you say to this question: Would you confine the instrumentalities used, as to the river, not only as to overflow, but as to navigability, to levees and revetment?—A. No, sir; I would not. I would supplement it by dredging for immediate effects.

Q. What would you say about contraction work—jetties, for in-

stance?—A. Well, the jetty principle is not applicable to the upper reaches of the river; it is only applicable to conditions existing at the mouth of the river. As to any works of that kind used in the upper part of the river, it is a misnomer to call it "jetty work." There have been contraction dikes made, not jetties, but transverse dikes, for the purpose of narrowing the channel; and the only objection to them is the difficulty of maintaining them.

Q. Well, I refer to all works where the volume of the water is contracted in space—where the channel is narrowed and the current made more rapid and stronger. For instance, the works at Horse Tail Bar; that used to be the worst bar between Cairo and St. Louis, and now there is no difficulty there at all. I understand that that has been done by means of these contraction works or jetty works. I have been so told.—A. Contraction dikes, I presume, is what was used. The conditions north of Cairo in the Mississippi River are quite different from those down in this part of the country. Practice has demonstrated, I believe, that such contraction works have been successfully made and maintained, and with very good results, north of Cairo. But experiments made south of Cairo have not proved successful because of the impossibility of maintaining the works. They perform their functions all right as long as they remain intact, but the foundation is so unstable down here, there is such an immense depth of unstable material to build upon, that the forces of the river attacking these works has invariably destroyed them. That has been the result of experiments made.

Q. You say you can not use these portable jetties south of Cairo?—A. Oh, yes; you can use portable jetties, I have no doubt—that is, portable wing dams, they are called. They would serve temporary purposes.

Q. Temporary only?—A. Temporary only.

Mr. CATCHINGS. To give a low-water channel?

The WITNESS. Exactly; to give a low-water channel. A great deal of the matter we have been discussing I have embodied in this paper [referring to a paper].

Examined by Mr. BERRY:

Q. Is it your opinion, from your knowledge of the river, that if substantial levees, properly constructed, 18 feet high, from Cairo to the Gulf, were made, that it would confine (barring accidents of course now and then) any quantity of water that has heretofore passed down the river?—A. Well, Senator, I could only answer that question as applicable to the part of the river that I am familiar with. I think that is true as to the river from Cairo to the lower limits of my levee district. Indeed, I believe that taking the whole distance to Cairo, that maximum would be diminished materially.

Q. It would be higher than would be necessary?—A. Higher than necessary.

Mr. NELSON. As you go up, the height would be less.

Q. But you are very clearly of the opinion that it is possible to confine by levees any floods that we have had in the past?—A. I haven't any doubt about it at all, sir.

Examined by Mr. CATCHINGS:

Q. When you say contraction works are not adaptable to the general improvement of the river, I understand you merely mean that they are not adaptable for use in all the bends as a part of the general system.—A. That is what I mean; yes, sir.

Q. But suppose you had a place where the river was unduly wide and filled with tow-heads and islands, where there were various channels, and you wanted to shut those off; in a case of that sort, would you not put in these contraction works or silt traps, so as to shut off the water from going around in the various channels among the tow-heads and islands and make it go through one channel?—A. Yes, sir; I think that lateral channels could be closed in that way so as to reduce the flow to one channel.

Q. I did not understand that you would object to them under those circumstances, but that you simply did not regard them as applicable to the general treatment of the various bends.—A. Well, I will say this upon that question, that the subject is not one that I have given very minute attention to. I only know in general that the river commission made experiments in that sort of construction and abandoned it because, as their reports show, of the difficulty of maintaining it. I see nothing in the nature of things why subsidiary channels may not be entirely closed by some such construction.

Q. Did they not abandon them merely as a means of concentrating the water so as to narrow the width of the river?—A. Well, they abandoned them as a means of permanently contracting the river. That is what they were first designed for.

Q. But they never did abandon them where it was necessary (as in the case I have cited) to shut off lateral channels and concentrate the water into one channel?—A. No; the original idea was to reduce the river permanently to a uniform width of about 3,000 feet, and these contraction works were designed to accomplish that, and they were abandoned as an agency to that end.

Q. Both because of the difficulty of maintaining them and because it accelerated caving opposite them?—A. Yes, sir.

Q. But they did pursue the use of them at Plum Point and other points where it was necessary to shut off lateral channels?—A. Yes, sir; and I have no doubt they can be applied very usefully in that way.

The witness then read the following paper:

CLARKSDALE, MISS., *February 1, 1898.*

Mr. CHAIRMAN AND GENTLEMEN OF THE COMMITTEE: The subject of investigation with which your committee is charged is one which must necessarily cover a wide field of inquiry. Assuming that you are willing to hear some expressions from myself on the questions involved, I will ask your indulgence while I make a brief résumé of the operations and policy of the Federal Government in its relations to the work of Mississippi River improvement.

The act of Congress providing for the appointment of a commission, composed of eminent and skillful engineers from both military and civil life, with an able lawyer to assist in their deliberations, was the first step taken, the wisdom of which is commended by all sensible people, as well as is the selection of those gentlemen who compose the personnel of that body.

The task imposed upon the Mississippi River Commission was to make a thorough study of the problem placed in their hands, by experiment and otherwise, and to determine what measures were practicable and expedient to be taken for the regulation and control of the Mississippi River in the interests of navigation and commerce. By later legislation, the protection of the alluvial lands adjacent to the Mississippi River by the construction and maintenance of levees has been recognized by the Federal Government as belonging to the duties of the river commission.

The river commission, by a thorough and exhaustive study of the subject, based upon careful and accurate surveys and measurements, have acquired all the theoretic information that is obtainable concerning the matters under consideration.

In the field of practical experiment they began with the proposition that the work before them consisted of three essential features, to wit: The contraction of the low-water channel by means of dike work; the revetment of the caving banks in the vicinity of these works for the protection of same, and the building of levees to confine the flood water to the channel of the river.

The relative importance of the three divisions of work was held to be in the order in which they are named above.

After several years of experiment, the contraction work feature was abandoned as impracticable because of the instability of the works themselves, though their intended functions were well performed as long as the dikes could be maintained.

It had then developed that bank revetment was of the first importance, and the levee building feature came second. Further experiments were made with bank revetment as a means of protecting caving banks.

These experiments were quite successful so long as the revetments held together and resisted the attacks of the current. But there was, after some years of service, a good deal of defection and failure, arising from weakness of construction or exposure to flank attack from isolation of the works.

The weakness of construction was due partly to imperfect information at that stage of the experiments, and partly to the limitation of cost to what was deemed within permissible figures.

One of the difficulties, and perhaps the greatest, under which the commission has labored in the course of their work has been that these experiments were necessarily made on a large scale and at large cost, and that in the nature of the case several years must have elapsed before any definite conclusions could be drawn as to the effects of any particular experiment.

The works were submerged beneath a great depth of muddy water, moving in violent currents, so that nothing could be known of gradual encroachments of the river until the time came for a collapse of the work.

Revetments have held with apparent permanence fo several years, only to go to pieces the next. These revetment works have been made stronger and stronger, with added knowledge gained by experience, until the more recent methods of construction are believed, with good reason, to possess all the properties of durability and permanence.

With increased efficiency of the revetment work, the cost has grown to about two and one-half times the first estimates, and the only obstacle in the way of further progress on that line appears to be the question of cost, the expediency of the expenditure necessary to accomplish the work as related to the resultant benefits being a question for the Congress to determine.

In the more recent operations of the commission more attention has been bestowed upon levee construction than in the earlier stages of their work, presumably because the levee feature, being an essential factor in the solution of the general problem, it was found that every dollar expended in levee construction brought certain results in palpable benefits without any of the uncertainties which have attended

efforts in other directions. This can not be regarded otherwise than as highly commendable from a practical point of view.

Now, if you will permit me to indulge in some expressions of my individual opinions as to the proper course to be pursued in furtherance of the accomplishment of the general purpose in view, to wit, the regulation and control of the Mississippi River in the interests of commerce and navigation, I will state my conclusions, which are derived from a somewhat intimate knowledge of the operations of the Mississippi River Commission gained from their official reports and my personal observations.

I will here take the liberty to remind the committee that, "in a multitude of counsel is safety," and in the opinions of any individual at least one idea of value may be found to contribute to the general fund.

If I may be pardoned for some unavoidable show of egotism, I will say that for twenty years past I have bestowed a good deal of my attention upon the subject now under consideration and have formed somewhat decided conclusions upon the general question as to whether the Mississippi River can be controlled and regulated to subserve the purposes of man and by what agencies the most beneficial results can be attained. These conclusions are based upon the exhaustive work of the river commission and are, I believe, in general accord with the conclusions of that able body of scientists. I assume as the first requisite that the channel of the river must be made fixed and permanent—held in one position. So long as this great river is permitted to roam at will hither and thither across its own alluvial valley all efforts to mitigate the evils of shoal navigation and overflow must be, in the nature of things, only temporizing devices.

The first requisite, therefore, to a complete regulation and control of the Mississippi River must be to give permanence to its banks. Otherwise all efforts to restrain overflow by building levees and to give low-water navigation by means of dredges or other devices must be mere temporizing measures, requiring continued renewals, because without permanent banks levees will cave into the river and must be renewed, and channels will fill up and must be dredged anew with each recurring low-water season.

When levees cave into the river new lines must be built upon on lower ground, because the slope of the land recedes from the river banks; and lakes and bayou channels must be encountered, thus greatly increasing the cost of maintaining levee lines intact along shifting river banks. Likewise, low-water channels for navigation, procured by means of dredges or other devices, must be renewed every year when the channel is continually shifting its position.

My conclusion is that without permanent bank protection and stability given to the position of the channel there will be a never-ending shifting of river banks and steamboat channels, a perpetual caving in, and renewal of levee lines on more expensive and difficult locations, and an endless expenditure of energy to remove obstacles to navigation at low-water periods, which must be reenacted with each recurrent low-water season.

To this larger enterprise it has been objected (1) that the cost will be too great and (2) that too much time will be required for its accomplishment.

To the first objection it may be said that the total cost of protecting all caving banks below Cairo has been estimated at $63,000,000 to $100,000,000. Accepting the larger estimate, the question to be considered by the Congress in its economical aspect is whether the

ıultant benefits of giving permanence to the channel of the Missis-
ıpi River, to the vast interests concerned, will justify the necessary
tlay; to which proposition I believe anyone conversant with the
bject will give an affirmative answer.

To the second objection it may be answered that the estimate of the
ıe necessary to be consumed in the work (forty years from Cairo to
cksburg) is based upon the fact that the supply of willow brush
ıwing on the bars along the river, which are available for such work,
sufficient for only 10 or 15 miles of bank revetment a year. But I
nk it will not require a great strain upon the ingenuity of the engi-
ers in charge of the works to enable them to utilize the branches of
ı myriads of forest trees that grow on the ground adjacent to the
er banks in many localities.

n any case, however, if it is conceded that the work is desirable to
accomplished and would be a profitable expenditure of the nation's
ney, and if forty years will be required to accomplish it, then I say
ıt the sooner it is begun the better, beginning at Cairo and proceed-
; downstream, with work perfected as it progresses. I believe, how-
er, that materials can be found and utilized for accomplishing say
ı-tenth of the whole distance per year; and that an annual appro-
ation of $10,000,000 per annum for ten years will be ample for the
rpose.

While Congressmen may look askance at these figures, it should be
ne in mind that the importance and value of the enterprise are more
n commensurate with the estimated cost; and that the welfare and
ısperity of many millions of people are directly and indirectly con-
ned in it.

n the meantime the levee systems, which have been making rapid
ides toward perfection during the past few years under the com-
ıed efforts of the local levee organizations and the Mississippi River
mmission, should be pushed to speedy completion; and immediate
ief to the navigation interests should be given by means of dredge
ats or other suitable agency, as experiment may develop that which
most efficient.

Furthermore, I would say, that if the present time is deemed inop-
rtune for pressing upon the attention of the Congress the matter of
ıking provision for the permanent work of regulating the Mississippi
ver, I should only plead for keeping alive that ultimate purpose, to
provided for after the accomplishment of the work of perfecting the
vee systems, and affording immediate relief to the necessities of the
ıvigation interests.

It is my own conviction that, while immediate restraint of the floods,
rough the agency of levees, and the immediate relief of navigation
' means of temporary low-water channels are pressing necessities,
t in the ultimate solution of the problem permanence of the river
ınks is a sine qua non, and I believe will in the end accomplish both
the purposes above mentioned. This belief is based upon these con-
lerations: The Mississippi River, throughout its length, or that por-
ın under our consideration, consists largely of a succession of reversed
nds in serpentine form.

These bends all have deep water and caving banks on the concave
les. Between the bends, at the points of reversion of the current,
vays occurs an expanse of wide and shoal water, what the pilots call
, crossing."

These shoal places constitute a series of submerged dams and afford
ı obstructions to low-water navigation. When the river is at flood,

usually very active caving of the concave bank goes on in each of these bends, which loads up the river water with a vast quantity of silt, all it can carry. Some material is taken up in the pools by vertical scour, but by far the greater part by lateral caving. This load of material has to be carried up to the summit of a submerged "hill" at the next "crossing," where the bulk of it is deposited for lack of sufficient current energy to carry it forward. This process is enacted at each successive "crossing," with the result that the shoal places are built up as the river rises. When the flood subsides the water is no longer surcharged with such material, and the increased slope on these bars, due to the obstruction they present to the flow of the river, causes their crests to be carried forward into the next pools below. So that there is an oscillation in the relative elevation of the shoals, as the river rises and then recedes.

Now, with permanent banks, and no caving, the material which is taken up in the bends and deposited on the bars will be reduced to that afforded by vertical scour alone, which constitutes a small percentage of that which is derived from lateral scour. The result must be, as it appears to my comprehension, that the bars will not build up as the river rises, because of lack of material by which they are so raised. On the contrary, the current, having all the energy incident to a flood stage, and comparatively little burden to carry, should scour off the crests of the bars at the reversionary points between bends, carrying the material to the next pools below and permanently deepening the water on the "crossings." Since the voiding capacity of the channel is limited by the depths of the shoal places, a permanent increase of those depths should increase that capacity, with the resultant of lowering the flood plane and relieving to that extent the strain on the levees

But further: The tendency to deepen the water on the shoal reaches by carrying their crests into the deep pools below, should result in a gradual approach to uniformity in depth of the channel and a realization of the dream of deep-water navigation at all times, from the Gulf to the head of the alluvial basin.

With regard to the levee problem, per se, and the feasibility of restraining the floods through this means, to the apprehension of an engineer it resolves itself into the simple aphorism, "enough dirt in the right place;" in other words, it is a mere question of dollars and cents.

The work of levee building, going back to its primitive stages, holds a very unique place in engineering annals. In every other department of practical engineering there is a definite purpose to be accomplished, the means for which can be measured and definitely ascertained before the work is undertaken. But levee building on the Mississippi River began a hundred years ago, with the instinctive efforts of individuals to protect themselves, much as a man who raises his hands to protect his face from the stroke of a switch as he rides through the woods behind a companion.

From such a beginning gradually developed levee systems, with very faulty locations and the crudest sort of construction. It was not until some dozen years ago that local levee organizations, stimulated by the encouragement of Government aid, began to treat the subject of levee building as a question of engineering science, to be conducted upon sound engineering principles. Prior to that era, all efforts at levee building were confined to the task of piling up dirt in the cheapest possible manner, so as, if possible with the inadequate means available, to keep the structure above the local high-water mark. The whole sys-

n a basis of temporizing work, as levees were expected to
into the river, the means at hand being insufficient to attempt
ike permanent locations or perfect methods of construction,
n being paid to foundations, or the removal of stumps, logs,
perishable matter from the base of the levees. The result
very undesirable legacy to the levee engineers of more re-
of a system of levees on very faulty locations, full of intrinsic
ns, which must perforce, for lack of sufficient pecuniary re-
come, or rather continue to be, the nucleus upon which mod-
ystems are built.
en my own effort to eliminate these imperfections as far as
herever they could be detected, but without entire success,
the only crevasse which occurred in my district during the
flood, due to a concealed defect in an old levee. But I have
to my old levees very extensively, and rely largely upon a
onderance of new material placed upon old levees, which
a small proportion of the completed levee, to counteract any
l weaknesses in the original structure.
emeal system of construction, resulting in a heterogeneous
consisting of many successive enlargements upon the original
l due to insufficient means to meet the requirements, have
l the great source of embarrassment to levee engineers.
task of anticipating increased flood elevations, arising from
onditions due to continued extensions of levee lines, so as to
ely exclude reservoir spaces from the reception of a portion
lume, has baffled the ingenuity of the wisest engineers, and
en compelled to be taught, mainly by experience, when expe-
nt disaster.
wever, has not been so much the result of want of foresight
t of means to meet the dangers, for we all anticipated phe-
od heights last spring from recent levee extensions, although
surprised by the remarkable elevations attained by the high

mate extreme elevation of the flood plane can not be accu-
rtained until the entire volume of some great flood shall be
etween levee lines. But so great advances toward that con-
have been made within the past few years that we can now
ith much more confidence than ever before the approximate
evation of the greatest floods that may be reasonably antici-
er such conditions. And, in conclusion, I can only repeat
ole problem of efficient levee systems resolves itself into the
enough dirt in the right place.
r respectfully,

T. G. DABNEY,
Chief Engineer, Upper Yazoo District.

mined by Mr. NELSON:

her from your paper that there was only one crevasse in your
1897. Is that correct?—A. Yes, sir.
e was that?—A. It was 48 miles below the head of the

it a very serious one?—A. Very; probably the most formid-
the river.
was the immediate cause of it?—A. There was undoubtedly
l, undetected defect in the old structure. The nucleus of the
was a levee built forty or fifty years ago, at a time when

levee construction was in its crudest state, and I had put only one enlargement on that levee on one side. It was an exceptionally high levee for the old system, and during the high water of last year, when it was 1 foot higher than that levee, it was kept from running over by topping it with sacks. Everything seemed to be in good condition there—good shape. No danger was apprehended, but a weakness developed by a leak issuing from the levee not far above the base, at the side of the levee. It did not excite very much attention; it was suppressed by sacks being put on it. Some days after, another leak developed above the first one, higher up the slope, and there were no hands immediately in the vicinity, but a gentleman who told me about it (Mr. McKenzie) was there and saw this other leak break out. He described it as being about the size of a stove plate. He called a negro who was within hailing distance, and they two laid a sack on it, and went to get another sack to lay on it, and, as they put that on, both sacks went out of sight, and in a little while it broke its way up to the crown of the levee. It could have been prevented if anyone had been there who understood how to treat such a case; it would not have been a difficult thing; five minutes work would have stopped it.

Q. It was a case of defective leveeing, not of too low a levee?—A. No, sir; defective levee. Now, during this year, in that vicinity, wherever the slope of the original structure has not yet been covered up, I have been making exploration ditches down into the old levee, and I have found dozens of large stumps that were buried there forty years ago, underneath the old levee.

Q. That will involve the reconstruction of that levee?—A. Yes. I am building on a new line. I can illustrate to you the situation. This is on the bank of what is known as Flower Lake, and this old levee was built quite close to that bank, as was the custom in those days. This is nearly east and west [drawing a sketch], the direction of the levee there; and at the lower end of this lake it turns about at right angles. Now, that crevasse occurred in that way [illustrating], the width of it being 2,068 feet. And there was a wall of water approximately 15 feet deep against the levee when the break occurred, so you can imagine what a volume passed through there. I am constructing a new levee more than half a mile above this break, because this crevasse water washed out a large hole behind an angle of the levee half a mile above it, and there was another hole on the outside there; there was a run around built in 1884 around the old 1882 crevasse. Now, this washed out a hole immediately behind, which obliged me to go higher than that to restore the line. So I have located a line in that shape [drawing], which runs approximately south forty-five west. From there it goes due west until it intersects this north and south line. I want to call your attention to the fact of the rather herculean task that I have had to shoulder.

The quarantine restrictions last fall and the general demoralization resulting from the fear of yellow fever, paralyzed all effort to accomplish anything to push the levee work during that period of the fall when it is expected the great bulk of it will be done; so I found myself at the end of the yellow-fever period with 350,000 yards of unfinished work on this line here, with an absolute opening between that and the Mississippi River; nothing could prevent the water from going through unless this 350,000 yards of work could be completed in time. Well, I had to take the matter out of the hands of the contractor; he was utterly unable to do it, and no outside forces were available, so I had to rob my own work elsewhere, wherever it would best bear awaiting,

order to concentrate my forces on this Flower Lake crevasse. I sembled a very large force there, but the rains poured down, the rms came one after another, and it looked as though it would be ysically impossible to finish he work in time. However, by persist- t efforts, by using every possible means, I have so far accomplished now that I am above any contingency of danger. I have three- urths of the levee entirely completed, and the other portion is now nsiderably higher than the water is at present in the river, and the ter has just about reached a stand. I am keeping it out there by the l of a protection levee built hastily. But I have been in a very ner- us frame of mind for a good many weeks on account of that.

Examined by Mr. CATCHINGS:

Q. I agree with you entirely that as an ideal system for controlling e river for navigable purposes (and incidentally also as a means of eventing overflow in time) it is desirable to revet the banks so as to ve fixedness to the channel. The cost of that revetment work, I lieve you said, was estimated at about $60,000,000 from Cairo to cksburg?—A. Yes. The estimate I made myself was, roughly, about e hundred millions from Cairo to the mouth of the Red River. Below e mouth of the Red River there is no revetment needed. My impres- n is that a hundred million is a maximum estimate from Cairo to the uth of the Red River.

Q. You put it at sixty millions to Vicksburg, then. The commission s estimated that it would cost $18,000,000 to $20,000,000 to perfect e levee system all the way to the Gulf?—A. Yes.

Q. What would you say would be the annual cost (taking into con- leration the contingency of the relocation and reconstruction of vees) of maintaining that whole system after completion?—A. The nual cost of maintenance, in other words?

Q. Yes; which would include such new levees as might have to be ilt.—A. I should say about 2 or 3 per cent of the original cost, ounting to about $1,000,000 annually.

Q. How much has been the annual renewal on the old levee line for 5 miles?—A. I can recall, I think, about how much new levee has en built since my connection with the district, approximately.

Q. I mean after you had once got your line fairly well established.— That is a question that can not be hastily answered without being swered in a haphazard way. I can go through my reports and look e matter up.

Major HARROD. Do you think that your experience or the experience any engineer in the past would be a fair criterion of the cost of aintaining a levee system after it had been completed and put in arge of the Government? Do you think the expense of that kind of aintenance would amount to as much as it has in the past, with the ferences of location and perhaps of construction?

A. Before I answer your question, Major Harrod, I want to say a tle more in reply to General Catchings, and it is this: That the annual ewals of levees in the Upper Yazoo district is much less than in any tension of levee below, and would therefore not be a fair standard which to judge of the annual cost of maintenance below.

General CATCHINGS. I took your front because of the experience at you have acquired in levee building. Levees are now better ated than they were formerly, are they not? They are not so liable cave into the river.

A. They are not so liable to cave. The caving along my front is ry much less than it is lower down the river.

Q. Is it not a fact that wherever levees are located now they are put at a much further distance from the river?—A. I think so. I know they are in my district.

Q. That has been the testimony we have had, that wherever levees are now located they are exempted as far as possible from danger by caving into the river; so, as time goes on, there would be less and less danger from that cause?—A. Yes, sir.

In reply to Major Harrod's question, I answer unhesitatingly that the annual cost of maintenance will certainly be very much less after the systems have been perfected.

Q. Suppose that the Government should decline absolutely to prosecute the work of revetment as a general system of improving the river, then is it not possible to accomplish the same purpose by means of levees and a liberal use of dredges; that is to say, can not the floods be kept out by levees, and the river made to supply a low-water channel for navigable purposes by dredging?—A. I think so. That is my opinion. The distinction is this, as I see it, that in the one case you get a permanent condition, and in the other a never-ending system of temporizing.

Q. But a low-water channel could be maintained by annual dredging and protection could be afforded by levees, and the Government would be likely to look at the matter from the standpoint of economy. Now, I want to ask you which would be the most economical. It has been estimated by the commission that after this revetment work was put in it would cost 10 per cent to maintain it; so that if you had your revetment work constructed to Vicksburg (and it would probably cost more than the estimate before you got through with it—that has been the experience of the Government) it would still cost $6,000,000 a year to maintain that revetment, and you probably would still have to maintain a very considerable levee system, would you not, at least for a good many years?—A. Yes, sir.

Q. Would it not be infinitely more economical for the Government to build these levees and be done with it, and incur such necessary expense as might come from caving banks, and improve the low-water navigation by the operation of dredges?—A. I would like to say this: With the system of indefinite temporizing that you have described, I am not prepared to say to what ultimate conditions that may lead. An indefinite extension of the temporizing system may ultimately lead to some very undesirable situations. That is a pretty deep question and it requires a great deal of consideration, I think, before pronouncing definitely upon it.

Q. I have before me the statement of the commission that it would cost from $60,000,000 to $70,000,000 to revet the banks from Cairo to Vicksburg, and that the annual cost of maintenance would be from $6,000,000 to $7,000,000. Now, would not that very extensive amount for maintaining the revetments be practically sufficient in itself, so far as you can now tell, to maintain a levee system, after once completed, and to operate the dredge boats?—A. Very probably so. Others are more familiar with those figures than I am, but I will say this: The estimate of the cost of maintaining the revetment, if it were once accomplished, I take it, must be in the nature of pure guesswork. I do not think there is any data upon which to base any such estimate with any confidence. It may be that it would not require anything to maintain it.

Q. Well, it would hardly be that. The nature of the structures themselves indicate that there would be some deterioration.

Mr. VEST. What did I understand you to state was the amount of the levee tax now in your district?

We have been collecting from $210,000 to $310,000, or thereabouts, ear. I think this year we will get $300,000. Replying in a gen- ay to your questioning, I do not think that engineers generally approve a system which looks forward to a never-ending tem- ıg as a substitute for making a completed system, whatever it be.

But I am talking about the cost of it now. Of course, everybody ncede that no matter what work you undertake in this life it would ter, if you had the means, to complete it in the most approved ı. But even with your revetment system, after it is completed, the estimate of the commission (because that is the best we there is a perpetual charge of six or seven millions annually to ain it.—A. I do not admit that, General.

Vell, assume that, because that is the best estimate we have got. hen, after you have built your levees at a cost of eighteen or r millions more, is it not likely that it would cost no more than seven million annually to maintain those levees and at the same ı operate the dredge boats?—A. I think possibly you are correct that. But in the meantime, what is the river doing? It is destroy- ousands of acres of land which can never be reclaimed under that a system; it is keeping the matter in a continual state of unrest dicision, and the necessity of renewing levee lines further back. that is a thing that is very undesirable to contemplate, I think. vhile I do not suppose the Federal Government is now in a frame d to undertake the larger enterprise that I have described, what ying to plead for is not a definite abandonment of it; simply to keep ı until a future time, when perhaps the Government will be willing t. Now, I agree with Colonel Stickney, that it would be very wise, herance of that general improvement, to keep some experimental going on all the time in the field of bank protection, even if no xpenditure was made—enough to still further develop the best of accomplishing the purpose.

Vell, I agree with all you have said, and yet I will ask this ques- vhich you can answer without any trouble): Is it not possible, use of levees and the use of dredge boats, to protect the Mis- ıi Valley from the floods and to furnish a sufficient navigable el for steamboats?—A. I think so. So far as protection from is concerned, I feel quite assured of the fact. Now, I am not ed of the latest developments in the dredging experiments. I t speak with so much decision upon that point. I believe, though, hat you have suggested is true; that those two things can be plished.

Examined by Mr. VEST:

Tou are familiar with the public sentiment among the people in evee district. How would the people in your levee district, as you know, regard the proposition to put up one-half, or dollar lar, with the Government, to raise the $18,000,000 to build these from Cairo to Vicksburg?—A. I think, sir, that the people of vee district would very cheerfully agree to that kind of an ement.

Have you any data as to the amount that is now paid each year levee districts from Cairo to Vicksburg? You say in your dis- is about $210,000, as I understand?—A. This year we expect, id before, to collect about $300,000.

Vell, say $300,000 a year, then. How many of these levee dis-

tricts are there between Cairo and Vicksburg, if you know?—A. I am woefully deficient in information about any other district than my own, Senator.

Q. But the people in your district would cheerfully pay one-half if the Government would pay the other?—A. I think they would be very glad to enter into such an arrangement. I am not sure but what there are some weak districts that might not be able to. The White River Basin, for instance, and the Lower Arkansas, have not enough territory to enable them to carry their half of the burden.

Q. Colonel Driver stated that he secured the passage of an act by the Arkansas legislature last winter, or at its last session, authorizing his levee district to issue bonds for $500,000, provided the Government put up $750,000.—A. I think I heard that statement made before the river commission by representatives of that district.

Mr. BERRY. That is true. But your district, Major, is much more able to pay than Colonel Driver's district.

The WITNESS. I presume so, sir.

Q. I am informed by my constitutents that that portion of the St. Francis district that is in Missouri has paid all it possibly can raise. It is not a rich district.—A. Perhaps I might suggest that the proposition suggested by you, of the burden being equally divided between the Government and the local interests, I think would not be applicable to those weak levee districts. I do not think they could carry their half of the burden. They have a very limited area as compared with the extent of their levee frontage. Desha and Chicot counties in Arkansas have a very extensive frontage.

Q. They are rich counties, though?—A. Well, in the aggregate I do not know. There is a good deal of low land there that is unavailable for use. And then the White River Basin has a small territory with a long frontage, and the St. Francis is largely undeveloped.

Mr. BERRY. Chicot and Desha are included with certain counties in Louisiana to make up the district, are they not?

A. Yes, sir.

Q. They do not make a district by themselves?—A. No; I believe Louisiana has contributed a great deal toward the maintenance of the levees on the front of the Lower Arkansas.

Q. Building what is called the Tensas district, there?—A. Yes, sir.

Examined by Mr. VEST:

Q. As I understand your testimony, it amounts to this: That unless we can raise the large amount of $100,000,000 for revetment, the best we can do is to make an appropriation of $18,000,000 for a tentative purpose; that is about the meaning of your testimony?—A. Yes, sir.

Q. I understand you to state that the $18,000,000 necessary to build these levees is simply a tentative expenditure—that is to say, that it is temporary, and we must at last rely upon revetment; that if we put up these levees (that will cost, according to the estimate, $18,000,000) it involves a continual expenditure to keep them up, and at last you have got to resort to revetment?—A. I think that is putting it a little strongly, Senator Vest. There is no doubt of the fact that you are right to this extent, according to my views, that after building those levees at that cost, after perfecting them so they accomplish the purpose in view, if the banks are permitted to continue to cave, there will from time to time (I can not say at what intervals) be a loss of a portion of the levee line that would have to be restored.

Mr. NELSON. It is only to that extent that you consider it tentative?

'he WITNESS. Well, I think tentative is the wrong word to apply.
Ir. VEST. Well, what word would you use?
'he WITNESS. I do not think it is tentative, because we can antici-
e with considerable certainty what is going to occur.

Examined by Mr. CATCHINGS:

). I understand you to mean this: That after the levees are built
y are not there to stay forever, as you build them, but owing to exi-
ıcies, such as caving banks, there will necessarily be, from time to
e, some relocations and renewals?—A. Exactly.
). And you are unable now to estimate exactly what that would be?—
Yes, sir.
). I wish you would try and form some estimate. It is desirable that
have a statement upon that.—A. It is not only desirable and impor-
t, but requires careful consideration. Now, I should like to talk with
confrères, Major Starling and others, who have some familiarity
h its history, and make up a careful statement.
). Of course, if the idea should get around that after you had
ıended $18,000,000 on top of $28,000,000 or $29,000,000 that already
'e been expended for levees, which would be something like a total
t of $46,000,000—if, after you have expended $46,000,000 in levees,
l they only last for a few years, and you have to spend $46,000,000
re, of course nobody would entertain that proposition; but if it
uld turn out that you would only have to spend a million a year, or
haps a little more, to maintain those levees costing $46,000,000, that
ıld be a very different proposition.

Examined by Mr. NELSON:

). Can you not put that proposition in this light: That the revet-
nt work, from your standpoint, is needed as a supplement to the
ees to prevent the banks caving and undermining the levees that
ı build; isn't that it?—A. Well, just the reverse of that. I regard
levees as a supplement to bank revetment.
). Well, take my view of the case for the time being, that the revet-
nt work in the curves of the river is to prevent the levees being
lermined and destroyed. Assuming that to be the case, then, does
the question, from a pecuniary standpoint, resolve itself into this,
to whether it is more expensive to maintain that levee by that
ıensive revetment work, which costs $30 a foot, or to maintain it by
construction of a newer levee within the leveed portion? Does it
resolve itself into that proposition?—A. Undoubtedly.
). And before you could fairly compare the two methods, that con-
cration ought to be given due weight. Now, if, after a careful esti-
te, it should turn out that it would be cheaper to run the risk of
ring your levees undermined at these curves, and curing the defect
constructing new inner levees, than by building the revetment work,
a mere matter of dollars and cents, the building of the new levees
uld be best, would it not?—A. Undoubtedly, sir.
). And, therefore, you should compare the cost of the two systems
the way of maintaining a levee constructed, should you not?—A.
s, sir. If the protection from overflow is the prominent or only
ect under consideration, I should unhesitatingly say that it is cheaper
ıuild new levees than to protect caving banks.
Ir. GALLINGER. But must you not keep in view the navigability of
stream constantly?
A. Certainly.

Examined by Mr. BERRY:

Q. I understand you to mean the levees (if we are not to abandon the country altogether) are a necessity to prevent the overflows, in any event?—A. Yes, sir.

Q. But you think, in order to keep the river in a permanent channel and prevent banks from caving, and the rebuilding of a portion of the levees from time to time, that the revetment would be the ideal thing, and a necessity to prevent any bank caving and to improve the channel, in order to keep the river in the same channel?—A. Yes, sir; that is true.

Q. In other words, abandoning the levee system altogether would be to abandon the country, would it not?—A. It would, sir. Now, I have stated repeatedly that I regard the speedy completion of the levee system as a pressing necessity. I think that disposes of that part of the subject. But I am endeavoring to take a much larger view of the whole subject than that which has to do simply with the protection of the country from overflow, or affording temporary relief to the navigation interests. I am trying to look forward to a time when we will have mastered the Mississippi River—reduced it to control—and the necessary step in such a proceeding is to give permanence to its position. Now, for all present purposes my own views are that the Government ought to take such steps as it is willing to aid in or to accomplish by their own efforts the completion of the levee system as speedily as possible, and giving relief to the navigation interests as speedily as possible by any temporizing devices that are available, and in the meantime to keep alive the ultimate purpose of absolutely controlling the Mississippi River, and to that end continue some work toward developing the proper methods and processes.

Examined by Mr. CATCHINGS:

Q. And when you spoke of the levee system being a mere temporary affair in the absence of revetment, you did not mean that the whole levee system would have to be renewed from time to time?—A. General Catchings, the instinctive feeling in my mind was that I was addressing myself to people who knew as much about levees as I do myself, which would preclude the idea that you have suggested—that it is merely a temporizing arrangement. Everyone at all conversant with the subject would know that the process of destruction of portions of the levee line would be a very slow one; that portions would be destroyed only at considerable intervals; and only from a more comprehensive view of the whole problem could it be denominated a temporizing system.

Examined by Mr. NELSON:

Q. Here is the river, say, and here is a caving bend in the river. Here is your new levee constructed as you want it under your new plan [illustrating]. That new levee, we will say, is threatened by the caving of the bank. Now there are two ways to remedy that; one is by building revetments and stopping the erosion of the bank, the undermining of it, the other is to let that erosion go on and construct an inner levee, is it not?—A. Yes.

Q. Now, then, in determining the question as respects the maintenance of levees, is it not a question of dollars and cents as to which is the cheapest (in the case I have supposed)—building this revetment for the purpose of protecting your levees, or building this new inner levee?—A. In such a case as that, Senator, you have stated the proposition correctly, as I understand it. It is merely a question of dollars and

ıts, in that view, involving the sacrifice of some territory and possi- r some improvements. There are cases, however, in which it would a serious question as to the relative cost of revetment or the con- uction of a new line. Ordinarily there is no question about the fact ıt the construction of a new line would be cheaper, but there are ses where there are old bends now in the form of lakes, and so forth, ere it would not be cheaper. I have such a case in my own district, ich I can illustrate very quickly. Mhoon Lake comes around like ıt, and is shoaled up at the two ends. Here is the Mississippi. ıre is a levee. Now this was threatened along here. It would be ry difficult to build that line any farther back, so, if it were necessary renew that, if that should become threatened it would involve the ilding of 12½ miles of new levee.

Q. In other words, then, there are cases where both from a financial ındpoint and because of the natural conditions revetment would be ɔ only remedy?—A. Where revetment would be the cheaper remedy.

Q. Yes, and would be practical in every shape of the case and the nedy that ought to be resorted to?—A. Yes.

Q. And there are other cases where new levees would be the cheaper d more feasible. Isn't that true?—A. Yes, sir.

Q. So that you could not lay down any uniform rule on the subject.—Well, I could say that the conditions I have just presented are ceptional, and the other is usual—to build new levees.

Q. In most cases would it not be cheaper to build new levees than to rry on the revetment work?—A. It would. Then, on the other hand, king a comprehensive view of the whole subject, it should be borne in nd that in a continued process of renewal by putting the lines farther ck (at least theoretically) there is a chance of its reaching a limit yond which you would have to stop.

Q. Yes, you might get a sort of endless chain.—A. Well, you would ıt back into more difficulties all the time, and you would be sacrificing great deal of property all the time, costly improvements, sugar houses, antation houses, barns, and all that kind of thing.

U. S. S. MISSISSIPPI,
February 5, 1898.

H. C. NEWCOMER, sworn, testified as follows:

Examined by Mr. NELSON:

Q. Captain, what position do you occupy?—A. I am in charge of the ird district of the Mississippi River, under the Mississippi River mmission.

Q. You are a captain in the Engineer Corps of the United States my?—A. Yes, sir.

Q. And in charge of the Third levee district?—A. No, sir; of the ird district, improving the Mississippi River, under the Mississippi ver Commission. That includes two levee districts, and several works bank protection.

Q. What districts does it include?—A. The Lower Yazoo levee dis- ct and the Upper Tensas.

Q. Where does the Upper Tensas extend from and to?—A. In a neral way, from the Arkansas River south to about the latitude of arrenton, Miss., 8 or 9 miles below Vicksburg, on the Arkansas and uisiana side.

Q. What is the mileage of levees you have on the west side? What is the distance from the Arkansas River?—A. It is about 185.1 miles.

Q. What is the average height of those levees above the ground?—A. About 13 feet.

Q. Are they completed to that stage?—A. They are in various conditions, of course. Some are fairly high, with reference to the last high water, although there are very few of that kind. Others again are lower. They are not uniform in their grade line. The money supplied has been used at different points of the line from time to time in raising the levee to a higher grade.

Q. When was the substantial beginning of the construction of those levees, either by local or Federal authority?—A. In that respect the district ought possibly to be divided into two parts, the part in Arkansas and the part in Louisiana. Formerly the district was divided into two parts, called the Upper and the Middle Tensas, but recently they have been combined into one. In Arkansas, although there were portions here and there along the bank prior to 1882, nearly all of the levee line, as it exists at present, has been built since that time.

Q. Since 1882?—A. Yes, sir. And the greater portion of that, I might say, has been built since 1892.

Q. The greater portion of the levee that is within the limits of Arkansas?—A. Yes, sir.

Q. How about the Louisiana portion of the levee?—A. In 1882 the yardage in place there was greater than it was in Arkansas, but at the same time the greater portion of that line, as it exists at present, has also been put in since 1882.

Q. Was there any continuous levee at the Louisiana end before that time, or was it only small patches?—A. I think the levee was practically continuous; that is, up to the low grade that was adopted at that time. In other words, the levee construction since that time has been mainly by way of enlarging the old lines or replacing them.

Q. Were you in charge of this division during the flood of 1897?—A. Yes, sir.

Q. At that time the average height of your levee was about 13 feet, you say?—A. Practically so; yes, sir.

Q. Now, state what your experience was with the high water during the flood of 1897, in respect to the levees under your charge.—A. The water during that flood generally attained a height of from 2½ to 3 feet above any former gauge readings throughout my district.

Q. You refer to the gauge readings of the prior floods, 1882, 1883, and——.—A. Yes, sir; the highest preceding floods. Of course the gauge varied for different years.

Q. And this time it was how much above?—A. About 2½ to 3 feet, as a general rule.

Q. Two and a half to 3 feet above all former gauge readings in your district?—A. Yes, sir.

Q. Your levees had been constructed on the basis of the gauge readings that you then had, I suppose?—A. Yes, sir.

Q. And were supposed to be sufficient, considering those gauges?—A. Yes, sir.

Q. If the water had not been higher in 1897, opposite your Tensas levee front than it was in 1882, 1883, 1884, and so on, those levees would have been ample?—A. I think so.

Q. And it was simply because the water was so much higher (from 2 to 3 feet higher) that your levees proved insufficient?—A. Yes, sir.

Q. Did you have many crevasses on your Tensas reach?—A. There were three in all in the Tensas levees in my district.

Q. Did those crevasses occur because the levee was too low or did hey occur through other defects in the levees? Did the water wash ver the levees and so make a crevasse, or did it work its way in aterally?—A. The actual causes of the crevasses are not known. In ne case I know, at the upper end of the system, where we had a small revasse that was of no real importance——

Q. What crevasse was that?—A. That was the Amos Bayou crevasse.

Q. That was the upper one?—A. Yes, sir.

Mr. BERRY. Where is that located, from the mouth of the Arkansas?

A. The levees begin on Amos Bayou, and go down Amos Bayou and ypress Creek to the Mississippi River, reaching the Mississippi River t Lucea Landing.

Q. Amos Bayou comes down parallel to the Arkansas, a little below t, does it?—A. Yes, sir. This crevasse was about 13 or 14 miles above ucea Landing along that line. It was only about a mile from the end f the levee, around which the water was already passing in considerble quantities. There is a gap——

Q. Yes; a 7-mile gap?—A. Yes, sir; between the Arkansas River ystem and the other, and of course large quantities of water pass hrough there at high stages.

Q. Was that crevasse in the Mississippi front of the levee or was it n the levee in front of Amos Bayou?—A. It was along the Amos Bayou?

Q. It was there where the levee broke?—A. Yes, sir.

Q. What was the width of that crevasse?—A. Between six and seven undred feet.

Q. Did that crevasse occur because the levee was insufficient in eight or through other causes?—A. That was through a defect in the ection of the levee. The levee had been constructed several years efore and had been badly gullied by rain wash, and the consequence as that these gullies almost met on the opposite sides, and reduced he section so much that it did not present sufficient resistance to the ressure of the water, and it broke through the base.

Q. It was a giving way of the body or base?—A. Yes, sir.

Q. Where was the next crevasse?—A. Near the lower end of the pper Tensas district.

Q. In Louisiana?—A. Yes, sir; about 3 miles below Vicksburg, on he opposite side. That is known as the Biggs crevasse.

Q. That was one of the largest crevasses that occurred, was it not?—. Yes, sir; it was a very important crevasse.

Q. One of the greatest that occurred during the whole flood anyhere along the river, was it not?—A. It did not attain any greater imensions than some others, but it was especially unfortunate on ccount of the very difficult location for a new line to replace the roken line.

Q. What was the length of that crevasse?—A. About 2,400 feet.

Q. How did that occur with respect to the levee?—A. That levee was ery low.

Q. Too low?—A. Yes, sir. It was topped up and the earth was kept bove the rising water; but it is claimed by some that the crevasse tarted on account of wave wash from a passing steamer being thrown ver the levee, and thus cutting down the topping that had been placed n it. But I am not sure of the reliability of that testimony. The ame levee had been giving a good deal of trouble on account of the loughing of the bank slope. Several times before that they had feared hat breaks were about to take place, but they managed to hold the line.

Q. Where was the next crevasse?—A. The Reed crevasse.

Q. At the lower end of your district?—A. Very near the lower end; yes, sir.

Q. How large was that?—A. It was about a thousand feet in width.

Mr. CATCHINGS. That was about a mile and a half below the Biggs crevasse?

A. Yes, sir.

Q. Are you able to give us information as to how much has been contributed by the local authorities toward the construction of that levee system and how much has been contributed by the Federal Government?—A. I can give you the yardage that has been put in by the two parties.

Q. Can you give the cost rather than the yardage?—A. I can not give that, because I do not know the amounts expended by the local organizations for the yardage they put in.

Q. Well, go on and tell us the yardage. Take first the Arkansas portion if you have that separate from the rest.—A. They are separate up to 1896. Since then I have combined them. My notes are not distinct for the two States since 1896 [referring to some papers]; but the greater portion of the work was of course done before 1896.

Q. And if you give us the 1896 figures, you will give us substantially what there is in it?—A. Yes, sir. I can give you what has been done since then also.

Q. Give us the Arkansas end of it, then, by local authority; and by that I mean the district and the State, everything outside of the Federal Government.—A. The records show that the yardage estimated to be in place in 1882 (before the Government took charge of any of the work) was about 1,788,000 cubic yards.

Q. This yardage before that was local work mainly, wasn't it?—A. Yes, sir.

Q. How much did you say that yardage was?—A. 1,788,000 cubic yards. Since then to 1896 the local authorities contributed 819,000 yards. During that same interval, from 1882 to 1896, the Government put in about 10,410,000 cubic yards.

Q. The proportion, then, in the aggregate, would be about ten and a half to two and a half?—A. Yes, sir.

Q. That is, ten and a half million yards to two and a half million yards?—A. Yes, sir.

Q. That is the Arkansas portion?—A. Yes, sir.

Q. Now come down to the portion in Louisiana. The greater portion is in Louisiana, as I understand it?—A. Yes, sir. In Louisiana there were in place in 1882, and therefore doubtless contributed by the local authorities, 3,181,000 cubic yards. Since then the local authorities have contributed 7,612,000 cubic yards, making a total of about 10,800,000 cubic yards.

Q. Contributed by local authority?—A. Yes, sir.

Q. And how much by the Federal Government?—A. The Federal Government has contributed about 4,800,000 cubic yards.

Q. I believe you stated a while ago that if the water level of the flood of 1897 had not been any higher opposite your district than in the flood of 1882 and 1883, the levees would have been sufficient, and that the gauge readings showed a higher level of from 2½ to 3 feet, as I understood you?—A. Yes, sir.

Mr. GALLINGER. But it does not follow that if the water had not been higher in 1882, 1883, or 1884 that you would not have had crevasses, does it?

A. Not necessarily, but I think we may practically assume that.

Q. I wish you would give, respectively, the local and Federal yardage of levee work in the Lower Yazoo district.—A. In 1882 there were in place in the line, available for future system, about 5,900,000 cubic yards.

Q. In the Lower Yazoo district?—A. Yes, sir.

Q. And since then, how much?—A. Since then the local authorities have contributed about 14,300,000 yards.

Q. Making nearly 20,000,000 yards?—A. Yes, sir.

Q. And how much has the Federal Government done in the meantime?—A. About 11,900,000 yards.

Q. A little more than half?—A. Yes, sir. I would like to correct that last statement in this respect. This statement, now, does not include the time simply from 1882 to 1896, but up to the completion of the contracts which are now in force. In other words, we have considerable yardage that is under contract, and that is included, so it really would take it up, say, to the end of this year.

Q. Well, does that apply to the other side?—A. No, sir. The figures I have so far given you apply to 1896. I have figures for the time since, for the district combined, but not for the two parts—Arkansas and Louisiana.

Q. Now give us the local and the Federal yardage since 1896 for the combined Tensas district.—A. The local amounts to about 691,000 yards. The Government construction, including the contracts now in force, will amount by the end of the year to about 2,618,000 yards. That gives a total contribution by the local and the Government operations up to the end of 1898 about the following quantities: The local, 12,303,943 yards——

Q. That is for the entire Tensas Basin?—A. That is for the entire upper Tensas Basin in my district since 1882.

Q. Including what was then on the ground?—A. That is simply the amount constructed by the local authorities since 1882.

Q. It did not include the amount before?—A. No, sir.

Q. But in your former statement you gave it?—A. No, sir; I simply referred to the amount that was in place and then I gave the amount built by them since up to 1896.

Q. You gave the amount in place and then added that and what they have built since together?—A. No; not in the amount that I gave you. The total I gave you before was simply the amount contributed in the two districts.

Q. Including the yardage in place in 1882 and all that has been done subsequently by local authority, including clear up to the present time, what is the aggregate yardage on the entire Tensas front in your district? That practically includes from first to last all the yardage that has been put in by local authority?—A. Yes, sir.

Q. What is the amount in yards constructed by local authority in the State of Arkansas up to the present time, so far as you know?—A. Up to 1896 the amount is 2,600,000 yards.

Q. And by Federal authority in Arkansas?—A. Up to 1896 about 10,400,000 yards.

Q. And within Louisiana by local authority up to 1896?—A. About 10,800,000 yards.

Q. And by Federal authority within Louisiana?—A. About 4,800,000 yards.

Q. And in both States combined since 1896 up to the present time by local authority?—A. About 700,000 yards.

Q. And by Federal authority in both districts combined?—A. About

2,600,000 yards. These quantities since 1896 include the work that is now in progress but not now complete.

Q. You stated before in your testimony substantially that the water during the flood of 1897 was on an average from 2 to 3 feet higher than it had been at previous floods?—A. Yes, sir.

Q. As a matter of fact, the flood stages at Cairo were a little higher in 1882 and 1883 than in the flood of 1897?—A. Yes, sir.

Q. And the volume of water was a little more, or at least as great?—A. Probably more; yes, sir.

Q. Probably more in 1882 and 1883. And notwithstanding those facts, the stage of water opposite your Tensas levees was from 2 to 3 feet higher than during those flood years?—A. The highest preceding floods in my district were in 1892 and 1893. As compared with these the flood of 1897 was from 2 to 3 feet higher, but as compared with the floods of 1882 and 1883 it was from 5 to 6 feet higher.

Q. How do you account for the extra rise in the flood of 1897 in your levee district, and to what do you ascribe it?—A. I ascribe it to the elimination of the basins that had formerly acted as reservoirs to a certain extent.

Q. That is to the closure of the basins above?—A. Yes, sir; and the construction here also of the levee system.

Q. The closure of basins and construction of levees above, and also the construction of levees here?—A. Yes, sir.

Q. In other words, to the construction of levees generally?—A. Yes, sir.

Q. How much do you think your levees ought to be increased or enlarged (to make them of a suitable size for the future) above the standard which you now have? Your standard is how much now on an average?—A. With reference, do you mean, to the height of the levees?

Q. Yes.—A. About 13 feet, say, at present, and they should be about 17½ to 18 feet; about 4½ feet increase probably in general.

Q. You would need an increase, say, to about 18 feet to make them safe for the future?—A. Yes, sir.

Q. And that is predicated on the idea that the levee system above is perfected?—A. Yes, sir.

Q. And that the river from Cairo down is confined within levees all the way?—A. Yes, sir.

Q. And you think, then, that an 18-foot levee would be what you would need, and would be sufficient on the Tensas Basin?—A. Yes, sir; I think so.

Q. Have you any idea what the extra cost would be to put your levees in that condition?—A. In the Upper Tensas district, including both the portions in Arkansas and Louisiana——

Q. That is your district?—A. Yes, sir—the estimated yardage, to give a grade of 6 feet above the flood of 1897 (which would give [illegible] about the increase in height to which we have referred) is abo[illegible] 24,680,000 cubic yards, costing probably in the neighborhood $4,000,000.

Q. At how much do you estimate it per yard?—A. At about 16⅔ cen[illegible]

Q. Now, will you give us the data as to the Lower Yazoo distric[illegible] have you given us the data in regard to the contribution, local a[illegible] Federal?—A. I think possibly I have given it.

Q. I meant, in the question I asked at the outset, to include yo[illegible] own district, divided up into two sections, one the Arkansas sect[illegible] and the other the Louisiana.—A. Well, what I gave a moment ago [illegible] plied only to the Upper Tensas, which is in Arkansas and Louisia[illegible]

e Lower Tensas is a continuation of the Upper Tensas, and is in the trict below mine.

Q. Well, we have covered your district then?—A. We have covered Upper Tensas, but not the Lower Yazoo on the Mississippi side.

Q. Well, that is not in your district is it?—A. Yes, sir; it is in my trict.

Q. Well, give me your figures then as to the Lower Yazoo district, to what the local authority has contributed, from first to last.—A. e local authorities, crediting them with the yardage in place in 1882, ve constructed all together about 20,260,000 cubic yards.

Q. Up to the present time?—A. Yes, sir; up to the present time, luding incomplete work, which is provisionally estimated; that is, as the yardage, of which I am not certain.

Q. What has the Federal Government done in the meantime?—A. It s constructed about 11,896,000 cubic yards.

Q. What is the height of the Lower Yazoo levee?—A. About the ne as on the opposite side of the river—about 13 feet.

Q. And it requires an increase in height to the extent of how much?— About 4½ or 5 feet.

Q. That would give you about an 18-foot levee?—A. Yes, sir; ctically.

Q. You need an 18-foot levee. And what will be the cost of the reased height to effect it?—A. The estimate of yardage required to ild to a 6-foot grade above the 1897 flood is 23,490,000 cubic yards, ring again an approximate cost of nearly $4,000,000.

Q. For the Lower Yazoo district?—A. Yes, sir. I think it might be ll to state that the figures that have been given concerning the earthrk constructed by the local and Federal authorities do not represent actual earthwork in place in the controlling levee line, because from e to time portions of the line have had to be abandoned.

Q. Have been washed away and abandoned?—A. Yes. So that to t at the actual present contents of the line, those portions abandoned lost would have to be subtracted.

Q. And that would hold good as to all reaches of the levee?—A. s, sir; probably one-fourth; in other words, of the earthwork that s been constructed is, you may say, to replace abandoned portions the line.

Q. What, in your opinion, are the best methods and means by which floods in the Mississippi River can be repressed or restrained and vented from doing damage by overflows?—A. I think the only cticable system is that of levees to secure the country from overflow.

Q. Have you any idea that anything substantial could be accomshed at any moderate or reasonable expense, by means of reserirs?—A. I believe not.

Q. Do you think anything could be accomplished by means of the called outlet system, that would be of any measurable benefit?—A. , sir; I think not, taking the question in a large way.

Q. It is true, is it not, that, owing to the character of the country, lets could not very well be made above the mouth of the Red ver?—A. There is only one outlet in existence that affects my disct, and that is the gap between the levee systems near the mouth of Arkansas River; that does act as an outlet at present.

Q. Which way does that lead the water to?—A. That leads the water t from the river into Bayou Maçon and Bayou Bœuf, and so on down, nging it back into the Red River.

Q. Inside of the Tensas?—A. Yes, sir.

Q. There is a possibility of a small outlet there?—A. There has been an outlet, relieving the flood height probably as much as 2 feet in this district.

Q. Are you of the opinion that it would be a good plan to leave that outlet from the Arkansas down there? Would that be a help? Do you think it ought to be utilized?—A. I think that it ought to be utilized until the levee system below the outlet has been sufficiently strengthened to discharge the additional quantity of water.

Q. You believe that that outlet should be maintained and utilized until you have properly fortified the levees all along the line, do you?—A. Yes, sir; I do.

Q. But you would not offer that as a permanent means of relief?—A. No, sir; I would not.

Q. But simply to be utilized pending the perfection of the levee system?—A. Yes, sir.

Q. Aside from that, there is no other point where outlets could be utilized or made available above the Red River?—A. Not that I know of.

Examined by Mr. BERRY:

Q. How much country does that outlet overflow there?—A. I believe that the area overflowed is comparatively small. I do not know that any damage of consequence was done during the last high water, when considerable water went out that way. Of course, it doubtless does interfere to a certain extent with the people along those streams.

Q. How did the water go down?—A. The water went down through the Tensas and the Black rivers into the Red River, and also partly into the Mississippi River, and partly through the Atchafalaya to the Gulf.

Q. What stream did it go into to go to the Tensas?—A. The levees along the Arkansas River start from the hills at about Pine Bluff and extend toward the mouth of the river to Lake Jefferson. The levees along the Mississippi River are carried back from the river up Cypress Creek and Amos Bayou to a point that was formerly supposed to be on high ground beyond the overflow, but, as a matter of fact, in that interval between the two extremities of the levee systems, there is a gap of about 7 miles, through which considerable quantities of water pass at flood stages, such as we have had in recent years. During the last high water it is estimated that about 120,000 cubic feet per second passed through there.

Q. Where does it go to then—into the Tensas?—A. It goes down through Bayou Maçon and Bayou Boeuf into the Tensas and Black rivers.

Q. Do you say it does not overflow any considerable amount of land?—A. There is considerable low land, I imagine, that is inundated, but, as I say, we have received no reports of any damage which was due to it.

Q. There is a considerable amount of land, is there not, that could be reclaimed if that water were confined?—A. Yes, sir. I say ultimately, when we have protected more securely the lands already reclaimed in the other basins and in this one, then it will be time to commence the reclamation of those lands.

Mr. NELSON. His theory is, you understand, that that should be left open until the levee system is made complete below.

Mr. BERRY. I understand. But I wanted to know what justice there was in overflowing that part of the country so as to protect the land in the other part of the country. I wanted to see by what line of reasoning a man arrives at such a conclusion.

The WITNESS. I understand, Senator, that the conditions have been that character for a long time in the past. In other words, in the otection of the different basins, parts of the country have been devel- ed under the protection of the levee system. That country has not t been so developed, and I do not believe it would be advisable to oceed to do so until security for the other basins is obtained. In fact, e safety of the people now living in that portion of the Tensas Basin Arkansas, who have been developing the resources of the country der the protection of existing levees, is much more dependent on the curity of these levees in their front along the Mississippi River than closing the gap at the head of the system. The closure of this gap present would throw an additional burden upon these levees that ey could hardly support.

Mr. BERRY. Have not many people in Desha County and along there ged the closing of that?

The WITNESS. Yes, sir; that has been urged by many people, but incipally by those living along the Arkansas River. As district ficer in charge of that district they have appealed to me a number of mes, but I have so far seen no sufficient ground for recommending to e commission an expenditure there while the available funds are tirely inadequate to satisfy more pressing needs elsewhere.

Mr. NELSON. Your opinion, then, is, in a nut shell, that that little utlet should be left open temporarily, as a safety valve, while you are erfecting the levee system of the river?

The WITNESS. Exactly.

Mr. NELSON. And after that is perfected you would close that open- ng?

The WITNESS. That would be my opinion.

U. S. S. MISSISSIPPI,
Greenville, Miss., February 5, 1898.

W. G. YERGER testified as follows:

Mr. Chairman and gentlemen of the committee, on behalf of the ard of trade and the community generally, we have appeared before u for the purpose of extending to you the courtesies of our city and so a little trip into the country for the purpose of showing you the ysical features of our region. We do not desire to trespass upon e time of the committee either in speech making or in trip making, t we thought it would really be a relief to the committee to make e trip rather than to hear speeches. But we do not desire, as I id, to press upon the committee the doing of that which may not be reeable or anything which the committee thinks would not be of nefit in the work in which you are engaged. So, representing the terests which we do, we will leave the matter to the committee to termine.

Mr. NELSON. We shall be very glad to hear from you gentlemen, d I want to say to you that we thank you very much for your invita- on to take the trip into the country, but we feel that we can perhaps do u as much good by listening to you and hearing your statements ere this afternoon, and we shall be glad to hear fully from you on all oints bearing upon the question of the levees, the floods, etc.

J. M. JAYNE, testified as follows:

I desire to state, as president of the levee board, that we feel sure that there is but one salvation for the river and the country, and that is levees. They will serve a double purpose; it will protect the alluvial delta and will serve the purpose which was intended by the River Commission, of maintaining the navigation of this river unaided. The incidental protection comes to us by virtue of these levees. We regard the levee system as absolutely essential both to our protection and to the navigation of the river. As you gentlemen know, we have expended millions of dollars ourselves; we have helped ourselves.

Mr. NELSON. That is true. You have done unusually well. Now, may I ask you a question at this point (not for the purpose of interrupting you, but for information): How would your people feel if the Government should see fit to aid you in perfecting the levee system of the river? Would they feel like contributing one-half the expense, if the Federal Government should contribute the other half?

The WITNESS. Why, Senator, of course. We have contributed seven-eighths heretofore, and I suppose we would be willing to contribute one-half. We would be very glad to do it.

Mr. NELSON. Your people would be satisfied if the Federal Government assumed half of the expense.

The WITNESS. I do not say that, but I say we will contribute our share. We think that this is a great national highway. We think it belongs to the United States Government. It drains twenty of the States, as you know. It comes from the Alleghenies on one hand and the Rockies on the other. The river flows down by us, and when it is forced down on us we must protect ourselves against that overflow. The water flows swifter now, because you have had your ponds drained, your forests cut down, and we here using this land are paying our tribute to the General Government, and most cheerfully, too, and we find ourselves absolutely deluged at times because of these increased conditions of overflow. Therefore, looking at this river as a national highway, as we understand it to be, we feel that the Government should take charge of this great artery of commerce. But if you can not do that, we will contribute our proportionate share, but in time it must come, because it is right that the Government should take charge of this great river.

Mr. NELSON. You believe, then, that it would be wise to put the administration and control of the levee system under the Federal Government?

[Applause by the citizens.]

The WITNESS. I not only believe that, but I believe, furthermore, that the true theory is, if you want to complete this system, to do it at once and not by piecemeal. If you undertake to do it by piecemeal, your levees will be washed away. If you are going to do it, do it at once and forever.

I desire to say that, so far as I know and so far as these people know, we are more than pleased with what the river commission has done heretofore, and we hope that they will be continued in charge.

Mr. NELSON. Please tell us how this flood affected you in 1897 immediately around your neighborhood. Was it at a higher stage than at former floods—those of 1882 and 1883, for instance?

The WITNESS. The water was higher. I do not mean that the discharge was greater than that of 1882, but the water was higher.

Mr. NELSON. How much higher, about, here? Was your town here threatened by it?

The WITNESS. No, sir, it was not threatened; part of it was overowed.

Mr. NELSON. I understand you have built a levee around your town ere?

The WITNESS. We are undertaking to do that now. When the levees roke in 1897 the water came in on the back of the town, and then we ırew up a little protection about that high [indicating about 4½ feet].

Mr. NELSON. That is on the north side of the town?

The WITNESS. Yes, sir. The levee board did not do that.

Mr. NELSON. Was your town inundated here?

The WITNESS. In 1897? No, sir; only a part of the town was, not ıe whole town. We have never been overflowed and we never intend › be overflowed.

Mr. NELSON. But you had to fight the water?

The WITNESS. Yes, sir.

Mr. CATCHINGS. What is the bonded indebtedness of this levee district?

The WITNESS. A million and fifty thousand dollars.

Mr. CATCHINGS. How many bonds have you retired issued heretoore?

The WITNESS. I can not tell you that. We paid up the indebtedness o 1880.

Mr. NELSON. What rate of taxation do your people pay for levee urposes?

The WITNESS. We pay a dollar a bale on each bale of cotton that is aised within the levee district—that is, within the levee we pay five ents an acre on each acre of land in the whole district, except in cities, owns, and villages. In cities, towns, and villages we pay five cents on ach lot or subdivision of a lot. Then we pay an ad valorem tax of five nills.

Mr. NELSON. That is based on the assessed valuation?

The WITNESS. Yes, sir. So we pay three taxes—the cotton tax, the creage tax, and the ad valorem tax.

Mr. CATCHINGS. And they amount practically to about 2 per cent.

The WITNESS. Yes, sir. Last year our revenues in this district mounted to $300,000.

Mr. NELSON. What did you say your ad valorem tax was?

The WITNESS. Five mills.

Mr. BERRY. That is the levee tax?

The WITNESS. All these taxes are levee taxes.

Mr. NELSON. All that you have given is purely the levee tax, as I nderstand?

The WITNESS. Yes.

Mr. NELSON. Is the valuation on which that is based nearly the cash alue of your property?

The WITNESS. No, sir; it is not.

Mr. NELSON. It is about half, probably?

The WITNESS. Yes, sir; I think so.

Mr. NELSON. But still it is a big tax, the three combined.

A CITIZEN. That 5 cents an acre is on unimproved as well as improved land.

The WITNESS. And in cities, towns, and villages, it is on the lot. ay you raise a hundred bales of cotton on a hundred acres of land, ou pay $100 on that cotton that you raise on that land. Besides that ou pay your ad valorem tax and you pay your acreage tax; so you an see what a terrible thing it is to this country.

Mr. CATCHINGS. The cotton tax has often been higher than a dollar a bale, has it not?

The WITNESS. Oh, yes. It was $4 at one time.

Mr. NELSON. Your average crop of cotton is how much per acre?

The WITNESS. I would say a third of a bale for the whole district. I think, as a matter of fact, there is no question but that we sometimes average over a bale to the acre in certain places.

Mr. NELSON. You can count, then, that the cotton tax amounts to about a dollar an acre on your cotton lands, at least.

The WITNESS. Yes, sir. And I will say this, also, that last year our cotton tax amounted to $160,000.

Mr. NELSON. In the district?

The WITNESS. Yes, sir. This year the cotton tax will amount, we think, to at least $150,000. The average tax in this district for the last eight years has been a little in excess of $250,000 a year.

Mr. NELSON. A quarter of a million?

The WITNESS. Yes, sir. Last year, as I tell you, it was a little over $300,000; but we had a very prosperous year—that is, had a very large cotton crop. If we have a good cotton crop, of course the amount collected increases; if we do not, it diminishes.

Mr. YERGER. I want to ask you to state whether or not you think it is the general desire or wish that the General Government should take this matter in charge and regulate the building of the levees and say where they shall be built.

The WITNESS. I do. I do not know, in all the range of my acquaintance, a man who would offer opposition to that. I have heard a great many affirmative expressions of opinion, and I do not know of a solitary instance of an adverse one.

J. M. JAYNES testified as follows:

I think it is due to the levee board and to these people to say to you that notwithstanding the high water of last year (probably the most disastrous overflow we have had in years) capitalists came in here and accepted our paper at a less rate than we have ever been able to dispose of it before.

Mr. NELSON. What rate do you have to pay?

The WITNESS. It has been heretofore at least 8 per cent. Last year we placed our securities on the market at the rate of less than 6 per cent. I do not mean to say, now, that we got that money at less than 6 per cent, but I mean to say it was six-months paper. But what I want to impress on you is this: That believing in the levee system, being assured that these people want to keep up their levees, believing in the richness of this country and its ability to survive the trouble that we have had, we placed on the market paper, after that overflow, at a less rate of interest than we have ever been able to do before.

Mr. YERGER. And while that is true, the credit and solvency of the district is limited. We would not be able to do all the work.

The WITNESS. I want to say, also, that these bonds were not floated in New York, not at all; they were floated here, within a hundred miles of home, from Memphis down. A great many of the bonds were taken here in Greenville.

LEROY PERCY testified as follows:

There was a question asked Mr. Yerger, that I can bear testimony on, and that is, the feeling of the people in this country in regard to the Government taking control of the levees. It is the earnest wish,

hope, and prayer of every man, woman, and child in the delta country that the Government take control of it; we not only are not opposed to it, but that is believed to be the only relief from the situation.

Mr. NELSON. Would that still be true if the Government were to insist that you still continue to contribute a share toward the repair of the levee by your local boards?

The WITNESS. That would depend entirely upon the share, in this way: There is no desire on the part of the people in the district, and never has been, to shirk any burden of taxation that they can bear. It is simply a question of their ability and resources.

Mr. NELSON. They would be willing, then, in your opinion, to turn over the control to the Government and still be ready to contribute according to their fair ability?

The WITNESS. Yes, sir. They would be willing to take whatever burden they had to carry, and take it without grumbling. The position is this: It is not like even the State of Mississippi being behind this levee system, but along this front you have been going along to-day we have a levee front of about 112 miles, and we have behind that, you may say, but a fringe of country; that is, this levee district which contributes this tax of, in the neighborhood of $300,000 a year, is composed simply of four counties; Bolivar and Washington counties are quite large counties——

Mr. YERGER. You said 112 miles; it is 212.

The WITNESS. And Issaquena and Warren are very small counties. It is the revenues from those counties that have been used to keep up a levee line of more than 200 miles in length, and whatever they can do in the way of bearing taxation they will do, as they have always done. They have taxed themselves as high as $4 a bale on cotton and 10 cents an acre.

Mr. NELSON. You have probably between three and four hundred thousand square miles within this basin, have you not, of lowland?

The WITNESS. Yes, sir; 290,000 square miles.

Mr. NELSON. Say 300,000 square miles, and at the rate you are taxed, $300,000 a year, that would be a dollar for every square mile.

The WITNESS. And there is probably not more than half of that under cultivation, and as to the land that is not under cultivation, its value depends entirely upon the future of the levee system. It is nothing.

Mr. NELSON. You get no contribution from the State outside of your levee district?

The WITNESS. Nothing whatever, sir.

Mr. NELSON. It is all taken care of by yourselves?

The WITNESS. It is all raised by local taxes.

Mr. CATCHINGS. This question has been discussed somewhat: That the Government should take control of the levees, assume control of them—should assume control of their repair and maintenance and their patrol, not only during the existence of high water, but during the existence of low water, it being suggested that the Government perhaps would be able to preserve them from misuse and abuse better than local boards—but at the same time that the people should contribute one-half of what is necessary to build them up to the required height and also one-half the cost of maintenance. Now, in that view, would the people of this levee district be willing to turn over their levees and let the Government administer the whole system, and let the Government spend the money which the people raise by taxation, as well as that which the Government should contribute, and let the Government do the patroling and maintenance?

The WITNESS. I do not think there would be the least friction about it—the least hesitancy about it. There is no feeling other than a wish to aid the Federal Government. The whole thing is, How can protection be secured? If we can once get the Government to say it will take control on any terms it means that probably every acre in this delta will be doubled in value simply by the announcement. For instance right here, on top of an enormous cotton crop, with a large part of the cotton in the field, with all the arrangements being perfected for the next crop, at a time when business should have been cash and everyone going into the next year's investments, three weeks ago the entire thing was paralyzed by apprehension and anxiety as to what would be the outcome of this present rise. It is the feeling of safety they are after, and they are willing to pay any price or bear any burden they can.

Mr. CATCHINGS. So you think upon those terms the people of this district would be willing to concede their levees and turn the whole thing over to the Government?

The WITNESS. Yes, sir.

Mr. CATCHINGS. And at the same time let the Government pay one-half and let the Government disburse the money and be responsible?

The WITNESS. Yes, sir; I think so. On the basis of one-half it would mean a higher taxation than we even pay now to contribute one-half to make a levee system such as the engineers say would be safe.

Mr. CATCHINGS. Well, the idea was that the whole amount would not perhaps be spent in a single year. But say, for instance, it was estimated it would take $3,000,000 to put the levees in this district into shape; now the Government would put up half and you would put up half, and the idea would be that it would take probably four years to expend all that money.

The WITNESS. They would undoubtedly raise it by taxation. They have raised $4 a bale, and they would raise whatever was necessary, whatever the Government would say would give security. There is a floating debt of a little over a million dollars, and of the $300,000 that we raise now a considerable portion of it goes to pay interest, and then we furnish all right of way, the Government furnishes no right of way, and those rights of way have to be paid for to the original owners. The board furnishes all of that, and also pays its engineering expenses. So, while there is a nominal revenue of $300,000 a year, there is probably not more than $100,000 that goes into actual dirt.

Mr. NELSON. You could probably complete your levee system here and get it into shape in your district for $4,000,000, say?

The WITNESS. Yes.

Mr. NELSON. And with half on the Government and half on you that would mean $2,000,000, and if that should be spread over a period of four years it would mean $250,000 a year, practically what you are taxing yourselves now; is not that correct?

The WITNESS. Yes, sir. And with that would come the increased value of property, which would enable the people to bear the tax much more easily.

Mr. NELSON. And after the first year you would be better able to bear the tax than ever before?

The WITNESS. Yes, sir.

Mr. CATCHINGS. It was testified by some of the witnesses that if the Government had control absolutely of the levees, that the levees would be likely to be better located; that is, in many places they would not be put so close to the bank, so that the loss from caving might be diminished. Do you think there is anything in that suggestion?

he WITNESS. Yes, sir. The matter of the location of levees in the ; has been a matter of necessity. The bank is higher near the river; efore a levee near the river requires less dirt, and it has been largely atter of patchwork, starting with almost an empty treasury, and he needs pressed they put the money where it was most needed and it as little as they could, so instead of making a uniform, well-ted line of levee, it is the result of twenty years of patchwork, and oubtedly a safer line could be secured by the Government adminis-ion of it.

r. NELSON. And I presume it is not only the financial aspect of the , but it is the feeling that the Government would be more inde-dent and less subject to be swayed by local prejudices and local rests in the location of the levees and would proceed on a more ematic plan in the work?

he WITNESS. Yes, sir.

r. NELSON. And it is that, as much as the financial question, that ates you in having the desire to put the system under the control he Government?

he WITNESS. Yes, sir; that is true.

H. WINN testified as follows:

entlemen, as to the point to which the chairman has directed certain iries as to the feeling of the people of this district as to their ingness to let the Government take charge of the levees, I can say, ink, without hesitation, that it is the unanimous wish of the people ; it be done, and the people would be willing to bear their just pro-ion up to one-half, or as much as possible.

ow, as to their willingness, the people would be more willing to tax nselves for levee purposes if they could feel that the object of that would surely be accomplished, and they would tax themselves much e readily, to a greater extent, feeling that the Government would up its proportion and the levee would be built upon a safe basis. ause many would say so long as it is left to local taxation that it is wing money away; that we are unable to do it by ourselves, but with assistance of the Government, and the knowledge that the levee em could be maintained with the assistance of the Government, ition would be much more readily imposed and the people would it much more readily. Now, as to the amount of tax, the com-ee, I believe, has been advised of the rate at which we are taxed. ollar upon every bale of cotton, which is in itself a high tax; an valorem tax of 5 mills, and an acreage tax of 5 cents on every acre es a large tax, showing what we have done heretofore, and our ingness. Now, if it is known to settlers that the Government will tribute, and will make the building of the levees a certainty, then people will be willing to tax themselves just as much as they can .

r. VEST. Suppose a proposition were made to the people of all e levee districts that the Government would put up as much toward construction of levees as the people of the districts would contribute make it one-half, but make it just as much as you put up), leaving the people of each district to fix the amount according to their ity or wishes, the understanding being that they would receive an unt from the Federal Government equal to the amount they put up, that much more would be expended by the Government upon their ricts, what would you say? Some districts are much more able others, and this proposition would equalize it. Your district

might only be able to pay $100,000; if it paid that much, the Government would put up $100,000 and expend it on that district, and that would raise the amount to $200,000. That would not oppress you, because you would fix your own tax: Do you understand me?

The WITNESS. Yes, sir. Well, sir, I would say that the people of this district would be willing, as far as they were able, to put up just as much as the Government, and they would be glad to put up as much as the Government put up.

Mr. VEST. I see by this pamphlet that you have put up much more than the Government has.

The WITNESS. We have heretofore, and we are willing to put up just as much as the Government, so far as it is within the power of the people to do it. You understand the taxation already is onerous. But if it were assured that the Government would put up enough in proportion as the people put up to make the levees a certainty, then I think there is no doubt the people would be willing to put up all they can and put up what the Government put up.

Mr. VEST. Of course this is on the assumption that the Federal Government would take hold of the levees and fix their location and determine the way in which the work should be done.

The WITNESS. Yes, sir.

Mr. VEST. That would do away with your State levee board.

The WITNESS. Yes, sir. The Government taking charge of the levees, as much as the Government contributed, they would contribute.

Mr. NELSON. This tax you speak of is imposed by general law, is it not, or is it imposed by your levee board?

The WITNESS. The acreage tax is imposed by the general law. The cotton tax is imposed by the levee board. Well, the whole thing is now imposed by the general law.

Mr. NELSON. That is, the law fixes the rate?

The WITNESS. Yes, sir. Formerly it was fixed by the levee board, but now by the general law.

Mr. NELSON. It would not require the action of any board to continue the taxation?

The WITNESS. No, sir.

Mr. NELSON. It would be left as it is—a matter of law?

The WITNESS. Yes, sir.

Mr. BERRY. I was under the impression that the law was that you could levy not beyond a certain amount; that the levee district could reduce that amount, but that you could not exceed a certain amount. Am I correct about that? That the State authorizes the district to levy taxes not to exceed a certain amount, and the amount up to that limit is within the discretion of the levee district, is it not?

Mr. JAYNES. No, sir; the law now fixes the tax on cotton, on acreage, and ad valorem. We have a right to reduce the tax not beyond a certain amount. For instance, one-eighth of 1 cent a pound on cotton (it is about that now); we can increase that, but we can not decrease it below a certain per cent. That is to say, we can not decrease it below one-eighth of 1 cent per pound on cotton.

Mr. YERGER. You can not increase the ad valorem tax beyond 5 mills?

The WITNESS. No.

Mr. YERGER. Nor the acreage tax beyond 5 cents?

The WITNESS. No; that is fixed by law, but the levee board does it, that is all.

Mr. CATCHINGS. Well, can you increase the cotton tax beyond a dollar a bale?

The WITNESS. We can increase it to a thousand dollars a bale.

Mr. CATCHINGS. And if, in any event, this plan Senator Vest suggests were adopted, it would require, of course, legislation on the part of your State as well as the Federal Government to perfect the plan; and of course in your legislature your own laws would fix the manner of imposing the tax on yourselves and raising your share of the contribution.

Mr. JAYNES. The law of 1886, I believe it is, authorizes us to turn over these lands to the Government whenever we see fit to do so.

W. W. STONE testified as follows:

On the question of the willingness of citizens of this district to contribute an equal amount in proportion as the Federal Government should donate it for us, that may be misunderstood by one of the answers made. We have in this district about 212 miles of river front. We have only four counties in the district, two of which are very small. The upper levee district, which has but a little over 100 miles of river front, has eight or nine counties and about three times the area that we have.

Mr. NELSON. Let me suggest to you in this connection that in such a plan as we are talking about the two districts could pool.

The WITNESS. The pooling had not been suggested.

Mr. NELSON. No; but they might pool and make the thing an entirety in the deal with the Government.

The WITNESS. Yes; but the Government would have to step in there, because the upper district, having a larger territory and less frontage than we have, has not been disposed to recognize the pooling question at all. We have been trying to form a pool, but have been unable to succeed, because they have got the "whip hand," and we have got the load to carry. And it might be well enough to arrange that so as to distribute the area of territory and pro rate it according to the frontage to be protected. Take the whole front here of 300-odd miles, and we have twelve counties to be protected, and the whole area ought to be considered with the idea of so much to——

Mr. VEST. Well, that is a matter of detail.

The WITNESS. Yes; but the detail, as it is going on record now, is the reason I want to call your attention to this. Judge Winn and Mr. Jaynes were asked if "you gentlemen living here are willing—here in your district." You applied it locally when asking the questions as to whether or not we are willing to be "taxed." That would be all right as an abstract proposition. It is very fair, perhaps. But if you go to the upper district, Major Dabney's district, and ask him if he is willing to do the same thing, he says, "yes." But then you are giving them, for one-half or one-fourth of the local burden we would bear, more money in proportion, a great deal, than you give to us for four times the local burden. It is an inverse and reverse proposition.

Mr. VEST. Well, of course it would have to be equitably distributed.

The WITNESS. Yes, I understand; but I do not want ourselves committed to the idea that our levee district, as a separate corporate entity, should be taxed for our whole front when the upper district, with more territory and a greater population to pay the tax, is taxed for less than we are when we protect a greater portion of the country. If you had taken the whole Yazoo delta and applied the question there would have been no question about it, I would never have said a word; but you applied it to us as a separate district.

Mr. VEST. Because we are in this district. We asked the same question in the other districts.

The WITNESS. Well, the other districts would answer yes, in the same way we do, but they could much more readily afford to answer it yes than we can.

GEORGE N. HELM testified as follows:

I have been connected since 1860 with the levees here. In 1858 the district was organized; it was an entirety then, all under one administration from Memphis to Vicksburg. Since, it has been cut in two, the upper and the lower district. In 1858 the organization was made. In 1860 I commenced upon the levees. We have been temporizing. Whenever we would have high water we would have an overflow, but it was restricted to some extent, and we got along a little better. We were fortunate enough in 1882 to get the assistance of the Government. There were so many breaks at that time that we were unable to protect ourselves, and when we got the Government aid we felt that we were safe—with the assistance of the Government. After the tax that we put upon ourselves we find we are still in the same experimental stage. It was unreasonable to expect to hold the water in with little sideboards of 3 or 4 feet; then we built 5 and 6, then 8 feet, and now we are building 12 and 15 feet high. Now, our hope of success has been diminished by the grand effort to confine the entire river. So we have suffered, really, by this general disposition to improve the general condition.

Mr. NELSON. The immense building of levees and closure of river basins has thrown an extra burden upon you here?

The WITNESS. Yes, sir; we suffer now just as the riparian owners who first settled in this country, when they yielded to a disposition to protect this back country. They were on the high lands, and the water went behind the plantations and they were all right; but, yielding to a desire to have the whole country improved, they agreed to tax themselves, and they built a line of levees to protect the back country. And there was a yielding on the part of the old owners here to those that were willing to go into the back country and settle it up—they taxed themselves for it. And so it is now; we all agree to the general improvement, but we find the same trouble; when we protect the whole thing we have got to keep the floods within these sideboards.

Mr. NELSON. And you are really in a more precarious condition today than when the country up above was open?

The WITNESS. Yes; and I can not see how a Government that we look to for protection will allow so many people on both sides of this river here to be endangered. Every time we have an overflow the statistics show hundreds of deaths from drowning. We send our navy abroad for one life, a debt of honor, and when we know we will actually suffer loss of life we make no effort to prevent it. I suppose this county lost a hundred people. This river is a natural artery of commerce. Why they should hesitate a moment I can not understand. We have a great population on both sides, and will have it quadrupled and quintupled if we have protection. People have confidence in these levees, and if we have the system completed we will be teeming with inhabitants. We have not a third of our lands under cultivation—I think not over a fourth. Give us protection and we will be teeming with people.

Mr. NELSON. Have any claims been filed here, either against your local authorities or the Government, for damage growing out of the construction of levees?

Mr. JAYNES. No, sir; except for rights of way. We are liable for hat, you understand.

Mr. NELSON. Yes; but outside of that?

Mr. JAYNES. No, not in our district at all.

Mr. NELSON. This Tensas levee on the other side was built after you ot your levees up, was it not?

The WITNESS. Yes, sir.

Mr. NELSON. And that gave you higher water, did it not—affected ou some?

The WITNESS. Not "some;" a great deal.

Mr. NELSON. Then the closing of the White River Basin affected ou some?

The WITNESS. Slightly. That did not hurt us much.

Mr. MONTGOMERY testified as follows:

Examined by Mr. NELSON:

Q. I understand, Mr. Montgomery, that you had a local levee debt ere in your district before the war of about $2,000,000?—A. We did, nd more than that.

Q. And after the war you paid that?—A. Yes, sir. There was a tax f 5 cents an acre on every acre of land in this delta to pay that debt, nd it has been all paid since the war; that is, in addition to the amount hat we have expended ourselves since that time on the levees.

Mr. GALLINGER. What do your taxes aggregate here, including your evee tax—the levee taxes and the other taxes added together?

The WITNESS. I think our State and county taxes, outside of levee axes, is 18½ mills.

Mr. GALLINGER. I would like to find out, relatively, your rate of axation here as compared with Northern communities. I am familiar ith my own country, and I know about what people are taxed there. ow, you have a cotton tax here of $1 a bale, or something like that?

The WITNESS. Yes, sir.

Mr. GALLINGER. That is a pretty heavy tax?

The WITNESS. Yes, sir. It amounts to $75,000 in this county—raised n cotton.

Mr. GALLINGER. Your State, county, and school tax all goes into one ax, does it not?

The WITNESS. Yes, sir.

Mr. GALLINGER. Now, how much is that?

The WITNESS. Eighteen and one-half mills; and then, besides that, here is 5 cents an acre levee tax.

Mr. GALLINGER. Five cents an acre and a dollar a bale?

The WITNESS. Yes, sir.

Q. There is a dollar a bale tax, a 5 cents an acre tax in the country, nd 5 cents a lot in the city, and an ad valorem rate of 5 per cent—5 ents a house lot in a village, I understand?—A. Yes.

Q. And 5 per cent ad valorem tax?—A. The 5 cents acreage tax is nposed upon wild land as well as improved land.

Q. And the 5 per cent ad valorem is upon real and personal property, oth?—A. Yes, sir.

Q. So you have three kinds of tax—a cotton tax, an acreage tax, and n ad valorem tax. Now, outside of that, what is your rate for other axes?—A. Eighteen and one-half mills for the State and county taxes.

Q. They etsimate, then, that this three-fold levee tax amounts, pproximately, to 2 per cent, and this other tax would make a rate of arly 4 per cent?—A. Yes.

Mr. JAYNES. And we who live in the city have a city tax of 13 mills, in addition to all that.

Examined by Mr. GALLINGER:

Q. We have heard a great deal, as we have come down the river, about a desire (that I think has been expressed here) to transfer this great project of leveeing the Mississippi River to the Federal Government, the levee districts or States paying a portion of the expense; and I think it has been generally stated that you are willing to pay dollar for dollar.

Judge WINN. We are willing to do that so far as we can, sir.

Q. There are districts that would not be able to do that, I take it?—A. I think so.

Judge WINN. Now, we take this view of it: That we would put as much money in to complete the system as rapidly as possible, getting rid of the danger of breaks. The district could not contribute as much at one time as the Government could, but it could contribute extending over a series of years. For instance, if it took $4,000,000 to put this levee district in absolutely safe condition, and the Government contributed $2,000,000, the district could not pay so much at once, you understand, but I think it is willing to contribute as much as it can, extending over a series of years.

Q. I suppose, notwithstanding all your taxation and efforts to protect yourselves, that you really are in a state of anxiety now, constantly?—A. Yes, sir; and will be until the levees are at that point where the engineers say they will be safe. The greater height to which we have to build is caused also by raising the flood line from having the levees completed on both sides.

Q. As I understand it, you did not have a break in front, but you had a break at such a place that the water ran in behind your town?—A. Yes, sir. A portion of this town was flooded. The residence where I live was flooded for six weeks.

U. S. S. MISSISSIPPI, *February 6, 1898.*

B. M. HARROD, sworn, testified as follows:

Examined by Mr. NELSON:

Q. Major Harrod, are you a member of the Mississippi River Commission?—Yes, sir.

Q. And have been so from the beginning, I believe?—A. Since the establishment of the commission, in 1879.

Q. What position do you hold under the State of Louisiana?—A. I hold none at present. I have been State engineer.

Q. For how many years?—A. For three years preceding my appointment on the Mississippi River Commission.

Q. And as such you had charge of the State levee system?—A. Yes, sir.

Q. Now, please give us such information as you can touching the matter of floods, the means of repressing or checking them (whether by leeves, reservoirs, or the outlet system, or any other plan), and give us such information as you can as to the past construction of levees and as to what ought to be done in the future in that behalf?—A. I think the whole leeve system and its success depends upon the question of whether the bed of the Mississippi River is rising, and, if it is, whether

that rise is to any extent caused by leeves. I would like to speak first on that subject—the evidence that exists concerning any movement of the bed of the river and the views I hold, and which I think the commission generally holds.

I believe a general division between rivers whose beds are raised and those whose beds are not raised is the distinction between gravel-bearing and silt-bearing rivers. Where gravel is deposited on the bed of a river it is generally put there to stay, and any change that subsequently takes place is the transportation of additional layers of gravel which are placed upon the previous one, and in that way the bed of a gravel-bearing river is liable to be elevated. I do not think that this process goes on in strictly silt-bearing rivers. Particularly I do not think it is true of the Mississippi River. The bed of the Mississippi River to-day is made of the material that the river is handling and is being handled day by day and year by year by the forces of the river itself. We have made a numerous series of borings from 100 to 200 feet below the bed of the river, and, with extremely few exceptions (one of which is in the neighborhood of Fort Pillow, and another in the neighborhood of Memphis, where indurated clay and lignite were encountered), we have met nothing but such material as the river is handling to-day—a mixture of clay and sand, sometimes a sandy clay, sometimes a clayey sand. If we struck gravel, it was very fine. But the general statement is true that the bed of this river for a depth below the bottom of any of the pools is composed of the same material that the river is handling to-day. From the annual or seasonal changes that are going on the capacity of the river to remove any part of its bottom that obstructs its flow is clearly demonstrated.

We find in our comparative surveys that a part of the river which at one time was shoal, having 6 or 8 feet over a bar at low water, in a few years, by the general downward movement of bends and points, has become a pool. The energy of the river has in localities removed 30, 40, or 50 feet of this material without any difficulty, and whenever it is controlled or directed it will be found able to remove any material that lies there to obstruct it.

The question of the elevation of the bed has been before the commission ever since its appointment, and the commission has made every possible effort to ascertain the truth in regard to it. I would like to make an appendix that was prepared by General Comstock in 1890 a part of my testimony before this committee. I presume you all know General Comstock, his character for great care, experience, and conservativeness. He prepared this appendix, weighing the evidences coming from the higher and lower stages of the river, and came to a well-defined conclusion that "on the Mississippi the records, while not extending over a period long enough to give final results, do not, as far as they go, indicate that the bed of the stream has risen." That is all I will read, but I would like to say that the part of the appendix referring to the bed of the Mississippi River is found in the Report of the Chief of Engineers for 1890 at pages 3096, 3097, and part of 3098. In connection with this subject he discusses the history of the Po and some other rivers. I would like to have this made a part of the report of the committee, if possible.

Q. My recollection is that the bed of the river Po has risen about one foot in two hundred years.—A. In certain parts it has risen. In other parts it has not risen, but has been depressed.

Q. But has not the aggregate of the periods combined shown a

rise?—A. The aggregate is a slight rise, particularly in the upper parts where to a certain extent it bears the gravel from the Italian hills.

The commission, in the last two and three years, has caused to be made a very careful resurvey of the river, having the ascertainment of the truth of this question solely in view. In 1882 and 1883 we made our original survey of the river. In 1895 and 1896 we resurveyed 400 miles of the river, from the Arkansas River to Donaldsonville. The cross sections that were made in the earlier period were, as far as practicable, repeated in the later period, and by taking so great a length of river we hoped to eliminate all local conditions and to be able to reach a final conclusion in the matter. But after making that survey with the greatest care we were entirely disappointed; the results were negative. The principal cause of that, I believe, is that the surveys were made at different stages of water, and the changes of stage of this river are so rapid and the time it takes to make a survey of this character is so long that it is impossible to make a resurvey on exactly the same stages as are desired.

Q. What did that result indicate, comparing the two surveys?—A. I will show you, sir. It is illustrated graphically in the reports of both 1896 and 1897. In the report of 1896 you will see [turning to a map] in that shaded line a profile of the bed.

Q. These two lines show the bed?—A. Those lines show the mean maximum depths at the two different surveys. From the extreme irregularity of them you will see that no general conclusion can be drawn. Computations have been made of all of these, and the text that accompanies this map gives you those computations, but the general result is that it shows no well-defined tendency either way.

Q. These lines are the mean maximum depths?—A. The mean maximum depths when the surveys were made; yes.

Q. Not at low water nor high water?—A. No.

Professor MOORE. May I ask what lineal dimensions that chart shows?

A. It shows 400 miles of the river. I think there are four of these charts; it is not shown on this alone, but the resurveys cover 400 miles from the Arkansas River to Donaldsonville. Now, in our report of 1897 we have shown this in a different way, which I think will appeal to you much more clearly. There are four of these sheets. This is a sample one. Localities where the mean river bed of 1895 at low water is below the mean river bed of 1882 are shown by the shaded areas. You will observe how contradictory that evidence is throughout the whole map.

Q. Can you give us any information as to the average amount of variance? Where there has been a difference, is the difference immense or is it slight—in feet or inches?—A. The difference generally is not great. Occasionally it is very great.

Q. In pockets?—A. Yes. That is to say, the general downstream movement of bends has been very great in some cases. For example, by these curves you will see an earlier section would come over a bar, and eleven years afterwards, when the other survey was made of this same cross section, in the same place it would come in a pool, and there the difference would be very marked, of course. I have been referring to comparison of cross-section elements, Vicksburg to Donaldsonville, plate 12, of the report of the Mississippi River Commission for 1897. There are four sheets covering these 400 miles. They are the same in character and they lead to no final conclusion on the matter.

There is a class of evidence which is within our reach and which is entitled to a great deal of confidence. It comes from the examination

of the low-water stages of the river, and I will cite one or two studies that have been made by the commission of that source of information. I will refer to the report of the commission for 1895. We have here the low waters of the previous summer—1894—the lowest water that was ever known on the Mississippi River. At ever guage from Belmont (which is 20 miles below Cairo) to College Point the readings, with the exception of three, were lower than ever known before.

Mr. BERRY. Where is College Point, Major?

The WITNESS. The first gauge before Carrollton, about fifty miles above New Orleans. Below that you get within the reach of ocean tides, and the gauges, of course, have no bearing on the subject. At Belmont, it was 0.6 foot lower than ever before; at New Madrid, 2.45 feet lower; at Cottonwood, 1.05 feet lower; at Fulton, 0.21 foot higher; at Memphis 0.45 foot lower; at Mhoons Landing 4.64 feet lower; at Helena, 2.05 feet lower; at Sunflower Landing, 2.44 feet lower; at Arkansas City, 2.66 feet lower; at Greenville, 2.86 feet lower; at Lake Providence, 0.4 foot lower; at Vicksburg, 1.4 feet lower; at St. Joseph, 3.74 feet lower; at Natchez, a foot lower; at Red River, a quarter of a foot lower; at Bayou Sara, 0.63 foot lower; at Baton Rouge, 0.45 foot lower; at Plaquemine, 1.14 feet lower; at Donaldsonville, 0.7 foot lower, and at College Point, 0.9 foot lower.

Of course, in looking over such a table as that, the first thing that would strike a critic is that this would be explained by there being a smaller discharge in the river than there ever had been before. But that explanation is negatived by the reason that taking all the tributaries of any consequence of the Mississippi River (including the Arkansas, the Cumberland, the Illinois, the Missouri, the Ohio, the Ouachita, the Red, St. Francis, Tennessee, Wabash, White and Yazoo) on none of them, with one exception, was the lowest stage reached during the low-water season of 1894. The supply from the tributaries was greater in 1894 than it had been in some previous years, yet the stage of water in the Mississippi, when those tributaries were combined, was far lower than it ever had been before.

Q. Have you no measurements during that low period of the volume in the river passing at a given point, so that you could compare the volume of water with the volume of other years?—A. I think we have low-water gaugings of our own river, but not of the tributaries.

Q. I do not mean the height, I mean the volume of water passing a given point.—A. Yes; I think such records were made during that low water, but none was made on the tributaries by us. They are without our reach.

There is another table in the commissioner's report for 1895 which I would like to cite. It is a table of lowest gauge readings in 1883 and 1894. Eighteen hundred and ninety-four is picked out because it is the year of lowest water. Eighteen hundred and eighty-three is picked out, not because it was a particularly low-water year, but because at that time the levees were in their worst state; it was immediately after the flood of 1882. I want to show from this table that in 1894 the depression of the low-water surface, within the limits of that part of the river which had been leveed from 1883 to 1894, was very much greater than the depression of the low water in those parts of the river which had not been leveed within those periods. From Cairo to Memphis in 1894 no levees had been built to speak of. There may have been private levees. The water within those limits from Cairo to Memphis, in 1894, was lower than the water of 1893, by the following figures: At Cairo 1.9; at Belmont, 3.8; at New Madrid, no change; at Cottonwood, 2.4; at Fulton, 2.9; at Memphis, 3.3.

Shortly below Memphis, about 20 miles, you enter upon the part of the river which is leveed, and that continues pretty much down. The figures I have just given you, you observe, range from zero to 3.3 feet and average 2.2. I will now give you the figures by which the water of 1894 was lower than the water of 1883 along the leveed parts of the river: Mhoons, 9.6; Helena, 8.6; Sunflower, 5.6; mouth of White River, 4.2; Arkansas City, 6.6; Greenville, 6.6; Lake Providence, 8.4; Vicksburg, 8.2; St. Joseph, 11.9; Natchez, 3.9; Red River Landing, 4.2; Baton Rouge, 2.7; Plaquemine, 2.4. And below that you get within tidal influence. The range is from 2.4 to 11.9, and the average is 6.4.

As a general result the depression of bed between 1883 and 1894 within those parts of the river that were leveed was from two to three times as great as on parts of the river where there were no levees.

I think this is a summary of the outline of the evidence that we have on this question. It leaves in my mind absolute assurance that the bed of the river is not raising, and that levees will not be found to produce that effect.

Q. To sum up, then, you do not ascribe the rise of the water in the river during recent years to any rise in the bed of the stream?—A. I do not.

Q. It comes from other causes?—A. It comes from other causes.

Mr. GALLINGER. Major, will you explain to the committee how it happens that the deterioration is so great between different points? For instance, at one point there is a difference of 11 feet, as compared with the former year, and at other points, say, 3 feet.

A. I would explain that by the extreme mobility of the material of which the bed is formed and its sensitiveness to any change of velocity or duration of current. The committee has shown some interest in the matter of the maintenance of a levee system after it is constructed. In what I am going to say now I wish to confine my remarks carefully to a completed and finished levee system. It has been shown by the experience of the commission that it is perfectly practicable to select levee locations that are good for twenty years. I would be safe in giving a higher figure, but we have been working up to that twenty-year limit without any difficulty. One-twentieth built every year makes 5 per cent of the levee system. But it must be remembered that about one-half of these levees are on banks which do not cave; on the contrary, they are making banks. So only one-half of the levees are subject to the danger of caving. That at once reduces the cost to 2½ per cent. If you had to repair the levees along the whole river it would cost you 5 per cent, but as you only have to repair them along half the distance the cost would be 2½ per cent. Levees that are built on batture banks, as we call them here, banks which are accretionary, do not require rebuilding. Sometimes, for the betterment and reclamation of land, they are moved out to the front, but that I do not think would be chargeable to the maintenance of a levee system. It is a betterment of the levee system, which is compensated for by the advantages that induce you to move it out there.

Q. Do you not think that where, owing to large curves in the river, which would necessarily lead to the building of levees farther out toward the bank of the river, where all of that advantage would inure to the adjoining landowner, that in those cases he ought to build them?—A. I do.

Q. And not the State or Federal authority?—A. I think so. That work should be done at his cost.

Q. And ought not to be charged up to either local or Federal author-
r?—A. No, sir. Now, if this 2½ per cent is assumed in the way I
ve described, and applied to the entire levee system, including all
e basins from Cairo below, it is rather less than $1,000,000.
Q. Has the commission any means or data by which you can deter-
ne the percentage of cases in which you have been obliged to move
ur levee on account of the undermining of curves in the river?—A.
s, sir; we have had estimates of that made.
Q. At how many points within the history of the commission have
u been obliged to remove your levees, or build inner levees—newer
es—on account of the undermining of the bank?—A. We have had
bles made for districts, showing the percentage of length within those
stricts for which the levees have had to be rebuilt.
Q. On that account?—A. Yes, sir. But the estimate I am making
w is not for such a system as we have had in the past, but for such
system as we hope to have in the future.
Q. Have you any data or means of ascertaining the number of places
the mileage where the construction of new levees has been entailed
on you in consequence of the erosion or undermining of bends of
e river?—A. Yes, sir; that can be furnished. Of course I accompany
y testimony on this point with the statement that the estimate I have
ade does not apply to such levees as we have had in the past, where
e locations have not been good, but my estimate applies to the expense
maintaining a completed system on good locations.
Mr. NELSON. Well, I would like to have you furnish us the data
vering the period since your commission began, both as to Federal
d State levees.
The WITNESS. We can furnish you that.
This estimate, applied to a complete levee system, is less than a mil-
n dollars a year. Beyond that there would be some slight cost for
pairs necessitated by wave wash and such little wear and tear as
kes place, but that would be a very small sum. I feel safe in saying
at 3 per cent would cover the maintenance of a levee system when
ll located and well constructed.
Q. Would not the chief expense of the maintenance of a well-con-
ructed levee system consist in replacements of levees owing to erosions
d changes in the river?—A. Yes, sir; by far the greater part. The
ar and tear of a levee that is perfectly constructed, sodded, and in
od shape, if the levee is not threatened by bank erosions, is very
ght. Its lifetime is very long.
Q. What do you regard as the best method of guarding and protect-
g yourselves against such inroads and destructions of levee as occur
m those sources?—A. I think every levee should be furnished with
telephone line, supplied with tool houses at fixed distances, say of 5
les, and the levees should always be guarded. Guarding the levee
time of low water would require very little work; one man could
ver many miles; but as the water raised the number of guards would
ve to be increased.
Q. The first remedy would be, would it not, of a preventive char-
ter; that is, first of all to get your levees constructed in such a place
at they would not be exposed; that would be the first thing?—A.
s, sir.
Q. And then where they are exposed, would you resort to revetment
rk to protect them?—A. I believe revetment work is hardly ever
cessary to protect levees, although there are some cases where it is.
the levees are well located and built at a season of the year that will

allow the sod to grow before the water rises over them the sod will generally give sufficient protection. I am speaking now about the revetment of the levee itself against wave wash in floods, and not of the revetment of the bank against undermining or caving. This I will discuss later.

Q. Now take a case where a levee is threatened by erosion of the bank. With the knowledge and experience you now have, which do you regard as cheapest and most economical to protect that levee by revetment work, or to construct a new levee in the rear of it? Which, on the whole, do you regard as the most economical and the wisest; not in all cases, but as a rule?—A. I think that depends upon the location of the levee, with reference to its proximity to the caving bank. If a levee is very near the bank, it is not worth repairing, but if it is a long distance away and has a long life ahead of it with regard to caving, it then does pay to enlarge, repair, or protect it.

Q. By revetment?—A. By any means; raising and enlargement, or rebuilding the outer slope.

Some interest has been shown by the committee concerning the difference in cost of the levee under the old system of appropriation and under the continuing system of appropriation. I would refer to a report made by Captain Townsend, which covers that point exactly, for a number of years, where appropriations were made by annual and then for the four years covered by our first continuing appropriation. The result of it is, that under the first system levees cost per yard 20.4 cents. Under the continuing or later system the average cost of levees was reduced to 11.7 cents in 1895. In the subsequent two years the cost has been gradually increased from 11.7 cents to somewhere in the neighborhood of 15 cents. This table will be found in the report of the Chief of Engineers for 1894, page 3628.

In connection with the increased height of the flood of 1897 above any previous flood, I concur in the statements that have been made by other engineers in their testimony, that it was caused by the rapid progress made in the building of levees since 1893.

Q. Then, as I understand it, you ascribe the great rise in the stages of the river down along the stream manifested by the flood of 1897 over the prior great floods to the increased and rapid construction of levees, and not to the raising of the bed of the stream?—A. I agree with you. I attribute it more to the work done along the White River Basin than to the work done on the Lower St. Francis Basin. Between the lower end of the St. Francis levee and the end of the Upper Yazoo levee there was a gap of 60 miles through which any engorgement of water that may have been caused by the new levees on the St. Francis Basin had an opportunity of escaping. I therefore think that the work on the White River front had more to do with the high water along the Yazoo front in 1897 than the work on the St. Francis levees.

Q. And the Tensas also?—A. Yes.

I would also like to say that it was the intention of the commission, as shown by its allotment, that the sum of three-quarters of a million dollars (each dollar of which would have built 6 or more yards of levee) should have been expended by the year 1897 on the Yazoo levees. The allotment was made by the commission with that object. And had the ruling of the Secretary of War, concerning our second continuing appropriation, been the same as the ruling of the Secretary of War as to the first continuing appropriation, there would have been an opportunity to have made an improvement of the Yazoo levees, which under the circumstances was not made.

Q. You could have made such an improvement of the Yazoo levee that it would have protected you against the abrupt closing of the White River front?—A. We intended to, and could have had them in very much better condition.

Q. But you were handicapped by the ruling of the Secretary of War?—A. Yes, sir.

Q. Please state fully what that ruling was.—A. Under the first continuing appropriation we were authorized, by a decision of the Secretary of War, to make contracts for the four years included in the appropriation.

Q. What year was that, please?—A. 1892. Under the second continuing appropriation (1896) our contracts were limited to the current year.

Q. Was there any difference in the law, so that the Secretary of War based his ruling on a different wording of the law, or was it simply a different construction of the law by the two Secretaries of War?—A. It was a difference in their interpretations.

Mr. CATCHINGS. There was a slight difference in the phraseology, but in my judgment it meant the same thing, and was intended to accomplish the same thing. The Committee on Rivers and Harbors, which framed the bill of 1896, so intended it, and reported in their bill to Congress that they had included the Mississippi River under the continuing contract system, and it was so stated by the chairman of that committee on the floor of the House, and it was passed upon by the Senate Commerce Committee, and passed by the Senate with the understanding that the Mississippi River was placed under the continuing contract system. We were all startled when we were told in the office of the Chief of Engineers that we had not accomplished what we intended to accomplish, so that under the present ruling it is not permissible to contract ahead.

Mr. NELSON. This was under the harbor act of 1896?

Mr. CATCHINGS. Under the harbor act of 1896. Under the law of 1892, as is the case now with all other continuing contracts, they might make contracts for work to be done ahead of the fiscal year, to be paid for only as appropriations might be made from time to time by Congress; the restriction was as to the amount which the Government could have been compelled to pay in a single year, but not as to the amount of work. But it has been ruled not only that the Government can not be called upon to pay exceeding a certain amount each year, but can not do work beyond that amount each year. I will add further, in this connection, that, realizing the difficulties, I went before the Committee on Appropriations at the last session (and several members of the Committee on Rivers and Harbors accompanied me), and we endeavored to induce the Committee on Appropriations to so amend the law as to comply with the most technical construction which could be put upon it, so as to place it where Congress intended to place it by the act of 1896.

Mr. NELSON. To make it mandatory?

Mr. CATCHINGS. Not to make it mandatory, but to make it clear that it was intended that they should have the power to contract ahead. But the committee declined to do that, or, rather, the chairman, between whom and myself the negotiation proceeded, and we were not powerful enough to compel it. Finally, in view of the exigencies that had been brought about by the breaking of levees here and there by the flood, it was agreed to add a cash appropriation of $600,000, so that they might anticipate to that amount, to be taken out of the future years.

Mr. NELSON. Without recognizing the principle for which you contended.

Mr. CATCHINGS. Yes, sir; without recognizing that.

Examined by Mr. BERRY:

Q. If I understood you correctly, Major Harrod, you state that the break on the Mississippi side was more to be attributed to the closing of the White River front than it was to the levees that had been built on the St. Francis River front. I will ask you if the closing of the Yazoo Basin on the Mississippi side would not have the same effect toward the breaking of the levees on the White River or Tensas side as the closing of the White River Basin would on the other side?—A. Any improvement in the way of levees on either side of the river has a tendency to increase, at first, the flood height. Those flood heights are dangerous inversely as the height of the levees on the two sides are. Where the levee is the highest, there is the least danger; where the levee is the lowest, there is the greatest danger.

Q. Then the closing of the Yazoo Basin would have the same effect in that regard as the closing of the White River Basin, would it not?—A. Had the conditions been reversed, yes.

Q. Now, if I understand you correctly, you believe that the complete or partial leveeing of the river has a tendency to increase the height of the water for the time being before any scouring process could occur?—A. I do.

Q. Now, I wanted to ask you whether or not, in the flood of 1897, the fact was that the water that went into the St. Francis Basin came out of the mouth of the St. Francis River while the flood height was still great in the main body of the river?—A. Yes, sir.

Q. Then, I will ask you whether or not you believe the water would have been any higher at Helena, if the entire St. Francis Basin had been closed, than it was in 1897 after the water joined at the mouth of the St. Francis?—A. I believe that the extreme height of the flood wave in 1897 was created by the return flood from the St. Francis Basin. Whether an equally extreme height would have been reached by the water confined and coming down the river, it is impossible to tell. I think the extreme height of the flood wave of 1897 was caused by the return flow of the St. Francis Basin.

Q. Whether or not it would have been higher or lower if it had all been confined, it is impossible for you to say?—A. Yes, sir.

Examined by Mr. NELSON:

Q. What was the average difference in height of the flood level in 1897, as compared with the flood levels of 1882 and 1883, through the country here, during the higher stages?—A. Along the White, Yazoo, and Upper Tensas basins I should say it was in some places as much as 5 feet. That was a great deal more than the average. At Vicksburg, for instance, it was not more than 3½ feet.

Q. It would run, then, from 3 to 5 feet?—A. Below Red River the excess of height in the flood of 1897 was not as great, because the rise and fall of the river is not so great, except at the upper end of Red River; from there down it constantly diminishes.

Q. What do you think was the average from Vicksburg to the mouth of the Red River, say?—A. I should suppose 2½ feet.

Q. Two and a half to 3 feet. It is evident, then, from your statement, that, to make a safe levee, you would have to build the levee to a height beyond that high water?—A. Yes, sir.

Q. That being the case, which, in your opinion, would be the safest nd most judicious way to proceed to the construction or building up nd fortifying the levees, to fortify the stream upward, or to fortify the tream downward?—A. I think in levee building the circumstances xisting along the banks make it necessary to protect from below up.

Q. That is the only safe and judicious way?—A. Considering proprty and life along the river, yes, sir. If it was a new and uninhabited ountry the course might be different; but I think the course I speak f is made necessary by the existing conditions of settlement along the iver.

Q. And that arises, does it not, from the fact that the building of evees and the penning up of the river within the levees of necessity nvolves an increase in the height?—A. Yes, sir.

Examined by Mr. GALLINGER:

Q. Let me ask you as to whether you are still of opinion, Major, that completed levee system from Cairo down can be consummated for 18,000,000 (which I think was a former estimate of the commission)?—A. I was a member of the committee that made that estimate, and I considered it an entirely fair estimate. The flood of 1897 has been so excessive that I would like to revise the estimate before expressing as nuch confidence as I had before, but my general impression still is that it is a fair estimate.

Q. Did I not understand you to say a moment ago that the cost of levee building within two or three years has increased some 20 or 25 per cent?—A. Under conditions that were unfavorable. In view of the conditions under which we were forced to build year by year. The heights that were suggested as probable ultimate hights in the report of 1896 I think, with two exceptions, turned out exceedingly well. The height that was suggested at Helena was overrun quite materially. The height at Red River which was suggested is rather excessive. But vith those two exceptions the high-water slope shown to be necessary y the flood of 1897 conforms in a very satisfactory degree to the one hat we had suggested would ultimately be necessary.

Q. We have heard a great deal, at the points where we have stopped, bout the desire on the part of the people to transfer this entire subject the Federal Government, the States or levee districts contributing a ortion of the expense. Have you given that matter any special nought; and if so, have you any suggestions to make to the committee s to a plan whereby that could be consummated, if it should be thought esirable, so as to protect all interests, and especially the Government?—.. I have thought of the matter. It has been brought to my attention, ecessarily. I think it would be very acceptable to all the people I now of living along the banks of the river. What the respective hares would be of course would have a good deal of effect, and I do ot think I am a good judge of that, but this I will say: that in the ast the people living along the banks have contributed a system of evees, such as it was, partially built. They have also contributed in he past fifteen or sixteen years while working in cooperation with the Government, a very much larger sum than the Government has contributed. I am quite sure that in the future they would be willing to ontribute what they are contributing now, fully; whether it could be nade more than the present contributions, I do not know. A great deal hat the States have contributed in the past few years has been derived rom the sale of bonds. Almost all of those bonds have been sold, and he time for redemption is coming, and for that reason I do not think it

would be possible that the net resources that could be applied to levee building could be as great as they have been in the past, although the people will be paying the same amount of money. The State of Louisiana has, I think, upward of $7,000,000 of levee bonds outstanding.

Q. The point that I more especially wanted to get at was as to whether you had given any thought, or the commission had given any thought, to any plan by which this matter could be practically transferred to the Government, and then the Government protected in securing from the local authorities such share of the expense as might be agreed upon?—A. No, sir; the commission has not.

Q. Has the commission given any serious thought to the matter of damages which might be claimed against the Government on account of the construction of levees? I understand there are already claims filed against the Government aggregating a very considerable amount. Now, assuming that the Government takes charge of this matter and becomes individually responsible, has the commission given any consideration to the possibility of enormous claims being piled up against the Government as a consequence?—A. None beyond the recommendation that was made in two or three successive reports referring the matter to the attention of Congress when the claims were made. The commission, after having done that, has done nothing more.

Q. Will you state in what reports that matter may be found?—A. In the reports of 1895 and 1896, I should say.

Examined by Mr. BERRY.

Q. I wanted to ask you if the difference between the flood levels in 1882 and 1897 was not about the same on an average along the river that the difference was at Helena? It was higher at Helena in 1897 than it was in 1882. It was higher at Vicksburg, and pretty much all other points. Now, I want to know whether or not the average was not about the same at Helena as it was at other points on the river.—A. The Helena gauge went higher with reference to the others, Senator, than I expected it would.

Q. With reference to its average, Major, I am talking about. Was it any higher at Helena on an average, as compared with what it was at Helena in 1882, than it was at other points, comparing those other points with 1897 and 1882?—A. No; I should not say it was, in the way you put the question.

Q. The average was not higher at Helena—the difference was not greater?—A. I think not. Of course it would take some computation to answer that question with certainty.

Q. There were some other points on the river where the difference was greater?—A. Yes, sir.

Q. And there were other points where it was less?—A. Yes, sir.

Q. The commission has estimated that it would cost between eighteen and nineteen million dollars to complete the levees from Cairo to the Gulf. Now, if (they were completed in such a way as you contemplate, do you believe unless there was some extraordinary accident) that those levees would hold the water, provided there should be no higher floods than we have had in the past?—A. Yes, sir.

Q. You believe that they would hold the water?—A. I do, with this limitation, which I made a few minutes ago, that the flood of 1897 was so excessive that I would like the opportunity of revising the estimate of $18,000,000 that we made. I do not know of any reason for doubting it, but I would not speak of it with the same confidence that I did before the flood of 1897.

Mr. CATCHINGS. You mean as to the sufficiency of that amount?

The WITNESS. Yes, as to the sufficiency of that amount.

Q. But you have no doubt, if the levees were completed in the way n which you contemplate (without regard to their cost), that they would old any such flood as we have had in the past, including the flood f 1897?—A. I have no doubt of it. My confidence comes from such nowledge as this, that there are many levees on the river 25, 30, 35, nd 40 feet high, and they are among the safest levees on the river. 'he danger of a levee does not increase with its height. Now, the aver- ge of the levees would be 16, 17, or 18 feet, or along there, but the onstruction of a 30 or 40 foot levee is known to be perfectly possible nd perfectly safe.

Mr. GALLINGER. In connection with this matter of damages, Mr. 'hairman, I would like to have inserted in the record the paragraph eaded "Consequential damages to lands," found on pages 3624 and 625 of the Annual Report of the Mississippi River Commission of 1895, n which it is very strongly intimated by the commission that the Gov- rnment may equitably be held in damages for levees already built, ven under the joint operation of the Federal and local authorities.

The paragraph referred to reads as follows:

CONSEQUENTIAL DAMAGES TO LANDS.

Since the last report of the commission information has been requested by the Law epartment of the Government, respecting damages to certain lands by overflow, id to have been caused by increase of flood heights in the Mississippi, in conse- uence of the building of levees under the direction of the commission, such infor- ation being desired for the guidance of that department in the defense of two its pending in the Court of Claims to recover such damages. All the information btainable on the subject was furnished and is accessible in the office of the Assist- nt Attorney-General, and the suggestion was made that information of a similar aracter respecting the effect of levees built under State authority should be added that furnished by the commission, which it is understood has been done.

The general subject of such injuries to lands in small basins was referred to in the st report of the commission. (Appendix XX, Annual Report of the Chief of ngineers for 1894, p. 2713.) The commission adheres to the views there expressed, id renews the recommendation there made that some provision be made by Con- ess for the adjustment of the equitable claims of land owners in such cases.

To what was then said it may be added that further consideration of the subject s shown in still stronger light the difficulty attending it. To ascertain the varia- ons of flood heights from year to year, to trace the causes of those variations to eir sources, to determine how far, if at all, they were due to levees built by the nited States and whether, if at all, they were due to levees built by the States or cal authority, and how much, if any, of the total injury suffered by a landowner due to an increased flood height caused by such levees, and how much, if anything, ight to be recovered from the United States for such injury, is a problem which ppears to the commission to be incapable of solution except by legislation designed id adapted to the peculiar and extraordinary circumstances of the case.

Examined by Mr. NELSON.

Q. The eighteen million estimate of the commission was made when?— . Two years ago.

Q. In 1896?—A. It appeared in the report of the commission for 896.

Q. It was made one year prior to the flood of 1897, was it not?—A. 'es, sir.

Q. At that time the commission did not apprehend that you would ave to build so high a levee as you now know would be required in onsequence of the flood of 1897. Is that not true? Your estimates ere then based upon the data that you had in respect to the floods of 882 and 1883?—A. Yes, sir; and 1892 and 1893.

Q. All the previous floods?—A. Yes, sir.

Q. And none of those floods indicated so high a levee requirement as the flood of 1897. Is not that true?—A. That is true.

Q. How much higher, in your opinion, would the flood of 1897 require you to build the levees than the prior floods would require you to build them, taking them as a basis?—A. I should say 4 feet; above Red River, of course.

Q. Then is it not a fact that in order to get a reliable estimate of the cost now that you would have to put into a levee, you would have to take into account the construction of a levee much bigger than was included in the eighteen-million estimate?—A. Somewhat bigger, not much bigger.

Q. From 3 to 4 feet higher?—A. What I have in view is that greater flood heights were reached by the volume of water which I think was discharged in 1897 than I supposed would be the case.

Q. But does not that flood of 1897 indicate to you that you will have to build a higher levee than you supposed you would have to build with only the flood experience of the prior years?—A. Very likely.

Q. How much; from 2 to 3 feet on an average?—A. I couldn't say. It is a matter requiring very careful calculation.

Q. Would it not be from 2 to 3 feet; on an average say 3 feet?—A. No; it might be an average of 3 feet above Red River and below Helena, between Helena and Red River. Above Memphis, say, it would be less than that, and below Red River it would be less than that.

Q. Well, in view of those facts your estimate of $18,000,000 (based upon former flood levels, if that was the correct one), this estimate is not sufficient for the flood level of 1897?—A. I think it should be revised. I think it is necessary to do so.

Q. Is it not a fact, in your opinion, that the complete closure and perfect closure by levees of the entire St. Francis Basin would necessitate even a little higher levee than the flood of 1897 indicated, taking that as a basis?—A. The more closing that is done the more preparation will have to be made by raising the grades of the levees, undoubtedly.

Q. Do you not think, then, that, taking into account the flood levels prior to 1896 and the estimate you made in 1896 of $18,000,000, that in view of the increased height of the flood of 1897 it would require over $20,000,000?—A. I think that is probable.

In the report of the Mississippi River Commission for 1896, on page 3460, is Appendix IV, being a report of the committee on levees, giving an estimate of increase of levee heights and contents necessary for the completion of the system.

Q. That was based on your prior flood experience?—A. Yes, sir.

Q. Now, do you not think that, as a matter of justice and fairness both to yourselves as a commission and to Congress, in view of the flood experience of 1897, there ought to be a reestimate based upon the grade necessitated by that flood?—A. I think, as I have tried to say, that it is absolutely necessary to revise the estimate, and I think it entirely likely that the amount will have to be increased.

Q. Materially increased?—A. I would rather wait until the revision has been made before expressing an opinion as to whether it will be large or small.

Examined by Mr. VEST.

Q. Supposing $20,000,000 was put into the hands of the commission, how do you think it ought to be expended for the best interests of the Government?—A. I know of no reason for changing the system the

e have hitherto pursued, except in such a way as would enable us to ake a distribution that would give more uniform heights in all the everal basins than we ever have been able to do before.

Q. Then you would apply it to strengthening the levees?—Q. Yes; om your last question I doubt if I understood your first question.

Q. Suppose $20,000,000 was put into the hands of the commission. low do you think it ought to be applied toward the improvement of e Mississippi River?—A. I should expend it between levees and redging. We have divided the money that has been put into our ands between dredging and channel work and levees. If the amount hat you speak of was applicable to all those purposes, I should continue some such division as we have made in the past.

Q. Do you not think under present exigencies, in view of the flood f 1897 and the damage it inflicted, that the whole of that amount ught to be applied, or much the larger portion of it, to strengthening he levees to prevent overflow?—A. I think I should continue the lredging, because it takes but a very small part of $20,000,000.

Q. And, except a small portion for dredging, you would put the alance on levees?—A. The operation of our dredges will be a matter f five or six hundred thousand dollars a year; so, if $20,000,000 were vailable, I certainly would continue dredging work, and build such ew boats as proved to be necessary.

Mr. BERRY. And the remainder of it you would apply to levees?

The WITNESS. Yes, sir.

Q. Do you not think it is absolutely necessary, under the present ircumstances, to turn the attention of the commission to strengthening nd improving the levees, so as to protect this country from overflow?—. I think so. I think their attention is turned to that and they ppreciate the necessity.

Q. What we may do hereafter is another question; but to meet present conditions and present danger, is not the immediate necessity to uild up these levees?—A. To build up the levees and to carry on the redging, which is a comparatively small thing in point of cost.

Mr. BERRY. You think, then, that for the protection of property hroughout this alluvial valley levees are a necessity, do you not?

A. I think they are an absolute necessity. Without them the country ould be uninhabitable.

Examined by Mr. NELSON:

Q. Can you state how many miles of levee are constructed within the risdiction of the commission?—A. I consider all of them below Cairo s to an extent under the jurisdiction of the commission—about 1,350 iles.

Q. How many more miles would it require to complete the system?—. I think about 100 miles more in the St. Francis—about 70 miles in he Upper St. Francis—that makes 170 miles for the two.

Q. That is above where you have started?—A. That is above New Madrid. Whether or not levees are needed or wanted there has always een an open question. To construct that system would take us above Cairo and out of our jurisdiction. We couldn't build that levee system——

Q. Then there is a little reach of 7 or 8 miles below the Arkansas River, between that and the head of the Tensas Basin?—A. Yes; there ould be 1,500 hundred miles of levee at the outside.

Q. Fifteen hundred miles from Cairo down?—A. Yes, sir.

Examined by Mr. Berry:

Q. What is the river distance from Cairo to New Orleans?—A. Nine hundred and sixty-three miles.

Q. And from New Orleans to the Gulf?—A. One hundred and ten miles to the passes.

Q. And from Cairo to the Gulf?—A. Ten hundred and seventy-three miles.

Q. Now, is it convenient for you to state how much in the aggregate has been contributed since the war by local authority toward the construction of these levees that are now built or under contract and what has been contributed by Federal authority?—A. I can not do it. Those statistics have all been compiled and can be furnished without any difficulty, but I can not carry them in my mind. There is in this book, I think [referring to the Report of the Mississippi River Commission for the year 1895], a table that covers a part of that. Here is the relative expenditure of the United States and of the different riparian States from July 1, 1892, to June 30, 1896. That is found in the Report of the Mississippi River Commission for 1895, page 3627.

Q. Have you the figures there?—A. In Missouri the United States expended $88,000 for 613,000 yards; the State of Missouri expended $208,000 for 1,387,000 yards. In Arkansas the United States expended $1,895,000 for 9,986,000 yards; the State of Arkansas expended $355,000 for 2,070,000 yards. In Mississippi the United States expended $1,050,000 for 6,293,000 yards; the State of Mississippi expended $1,112,000 for 6,109,000 yards. In the State of Louisiana the United States expended $2,967,000 for 12,368,000 yards; the State of Louisiana expended $3,874,000 for 21,566,000 yards.

Mr. CATCHINGS. That statement, Major, only covers the four years, from July, 1892, to July, 1896?

The WITNESS. From July, 1892, to June 30, 1896.

Mr. NELSON. And there are two years subsequent to that.

Mr. CATCHINGS. I understood Senator Nelson to ask what the total is.

Mr. NELSON. Yes; since the war.

The WITNESS. Well, all that can be furnished, and will be.

Q. Have you any statement to make as to the matter of outlets or reservoirs?—A. The subject of outlets has been thrashed out, I think, more thoroughly than any other problem connected with the physics of the river, and I hardly think it is worth while to say much about it. The law of sedimentary streams is probably illustrated better in the Mississippi than anywhere else. It is sedimentary to a greater or less degree throughout its entire length, and as you start from the head waters and come down, as the volume increases the slope decreases with a regularity that is very beautiful to observe when flooded. That continues until you get to the head of the passes, and then the single river is divided into three or four other rivers, and the slope immediately increases from 1¼ inches per mile to 3 inches per mile. That is because the volume of water is subdivided and its power is partly lost. Any outlet of any great magnitude in Louisiana below Red River would be substantially carrying the head of the passes up the river to where that outlet was opened, and the conditions of slope that now prevail in the passes themselves for 10 or 12 miles would prevail throughout the river up to this outlet, which would be, say 100 miles, and the consequence of that would be that the surface of the river above there would be raised.

Q. You regard it simply as a transfer of the head of the passes up, then, to where outlets were made?—A. Yes.

d you would get a number of smaller channels?—A. You would
› increased slope, which results from subdivision of volume,
sea up, not 12 or 15 miles, as is now the case, but for 100 miles,
ver the distance might be, to the head of the Delta. That is a
al consideration of outlets. A practical one, that appeals to
strongly, is that any outlet you make is a river, and has got
eed. You want to get the water out of the river, but you do
; to get it on the land. So, when you make your outlet you
› to levee it to the sea and restrain it in the same way that you
ain river itself. If you have 100 miles to the sea, you will have
200 miles more levee, and the cost and danger attending levee
tion and maintenance is in proportion to its length. So you
ally increase the care, expense, and danger to this extent.

xamined by Mr. VEST:

what?—A. By building these outlets and increasing the length
to restrain them, which has to be attended to in high water.
seems to me, though, Major, that the practical question is what
t to do with the present outlet—whether we ought to close
l open up the Southwest Pass, or leave the South Pass open
. open the Southwest Pass, or abandon the idea of opening the
st Pass and leave the South Pass as it is and improve it?—A.
at is not within the jurisdiction of the commission; but I have
l defined views about that.
ll, I would like to hear them. It does not make any difference
it is within the jurisdiction of the commission or not.

xamined by Mr. GALLINGER:

fore the Major answers that question I would like to ask him
tion about this outlet system (which of course does not relate
asses). You say, Major, that this additional length of water
whether it is a hundred miles more or less, would have to be
n both sides?—A. Yes; it would have to be excavated and
eed.
t in addition to that is there any certainty that you would not
actically all the water through that pass and leave the country
randed, out on the banks of the river, or is there any absolute
that you could divert enough through the pass to relieve the
ove?—A. In connection with that suggestion, I would use this
on: This river is full of islands, and every island has a chute
. There is not an adjustment, an equilibrium, anywhere on
between the main stream and an island chute. In every case
is filling up or it is deepening and enlarging. It will either
or else at some time the river will go into the chute. So
outlet. It will prove to be absolutely impossible to build an
ich will have a stable relation to the main river. It will either
close up and require perpetual dredging or else it will enlarge
me the main river. It will be impossible, designedly, to build
having permanently the desired capacity. You might hit it by
, and that would be the only chance. You could not expect to
ch a result.
ERRY. And the idea of making a permanent outlet from the
cis Basin to the Gulf would involve such an immense cost as to
mpracticable, would it not, Major?
ink it is possible.

Examined by Mr. NELSON:

Q. In connection with this outlet matter, there is for the time being a very small outlet in tne Tensas Basin, back of the Tensas River there, that goes out in that 6 or 7 mile gap below the Arkansas River, is there not?—A. Yes, sir.

Q. Through that bayou there?—A. The levees of the Arkansas River and Amos ridge systems overlap each other. The overlapping is not sufficient to exclude all backwater.

Q. Would it not be well to leave that outlet open for the time being, until you get your levee system better fortified?—A. The Amos Ridge levee has been strengthened with a view to making it safe from overtopping, but I do not think there is any intention at present to extend that line any higher up.

Q. No intention to close it for the present?—A. No, sir.

Q. Of course, in time, it ought to be closed?—A. It ought unquestionably to be closed, in time.

Mr. CATCHINGS. Major, I would like to have you say something about the question of cut-offs, if you will.

The WITNESS. The last cut-off, I think, was Waterproof Cut-off. That occurred in 1884. The length of the river was reduced 12½ miles. A resurvey was made (which I have shown you to-day) with a view of ascertaining what was going on in regard to the bed of the river. In 1895 it was ascertained by that survey that the river had recovered, out of that 12½ miles, about 5 miles of its length, and by this time it undoubtedly has recovered still more, so the effect of shortening the river and increasing the velocity by a cut-off is not permanent, but is measured by ten or twenty years certainly. Within twenty years after the occurrence of the Waterproof Cut-off its effect on the length of the river will have disappeared; but in the meantime immense quantities of bank, of levees, and of valuable real estate and improvements will have been caved into the river to enable it to regain the length which was lost.

Reference might be made to the cut-off at Vicksburg. That occurred before the art of bank revetment had made any real progress, and therefore it was impossible to prevent it. But could $200,000 to $300,000 have been put into good revetment on the upper side of Vicksburg Point, it would have saved upward of $2,000,000, and would have enabled Vicksburg to maintain the commercial position which she can never entirely regain. A quarter of a million dollars would have prevented that cut-off. Now, we know something about revetments and appreciate the danger of cut-offs, and we are using very vigorous efforts in two places to prevent them. One is at Ashbrook Neck (a short distance above Greenville), the other is at Cowpen Neck (just above Natchez). The effect of either of these cut-offs would be to largely increase the caving in all the bends above and occasion the loss of levee and real estate, and, in the case of the latter point, it would immediately destroy the harbor of Natchez, depositing a sand bar along the whole front.

Mr. CATCHINGS. With no compensating advantages to commerce?

The WITNESS. With no compensating advantages to commerce.

Mr. VEST. Senator Caffery, on two different occasions, said to me: "Do not fail to notice the Atchafalaya River, and to observe the great danger there is of the Mississippi River being diverted through that river and abandoning its present course." What have you to say on that?—A. Well, sir; I hope you will take a look at it to-morrow morning.

Q. Well, will you state your opinion of the possibility of that?—A. ere was a great deal of apprehension of that some years ago, and haps there was some foundation for the apprehension; there seems have been enough, certainly, for the Mississippi River Commission get an appropriation and make a project for the prevention of anyng of the sort. That project consisted in the construction of six sill ns, one after the other, about a quarter of a mile apart, across the chafalaya, with a view to preventing a further enlargement. We ut to work and built two of these dams. Surveys have been made intervals since, and we have kept a watch on the locality, and there o evidence of any necessity for building any more than the two of six dams that we already have. Should there be occasion to build re we would immediately do it.

Examined by Mr. NELSON:

Q. Is it not the tendency of more recent times for the Atchafalaya her to become an outlet for the Red River than the Mississippi? at is, does it not lead directly out of the Red River before the Red ver effects a complete junction with the Mississippi?—A. Yes. The pacity of the Atchafalaya, however, is larger than that of the Red.

Q. Yes, but I mean the head of the Atchafalaya is directly out of the d rather than directly out of the Mississippi?—A. The mouth of Red and the mouth of Old River are about 9 miles apart. The head the Atchafalaya is between them, 3 miles from the Red and 6 miles m the mouth of Old River.

Q. And how far from the mouth of the Red River where it flows into Mississippi?—A. Well, you come down Red River to its mouth; en you go along Old River 3 miles to the head of the Atchafalaya; en you pass the head of the Atchafalaya and go over Old River 6 les more, when you get into the Mississippi.

Q. So there is no direct connection with the body of the Mississippi?— No, sir; only through Old River.

Q. The connection is more immediate with the current of the Red?— Yes, sir; in distance and direction, both.

Q. And on that account the apprehended danger is growing more note?—A. The danger is one that can be controlled and is being tched. The enlargement of the Atchafalaya started from the removal the dam by the State of Louisiana in 1845.

Mr. VEST. Senator Caffery's apprehension seems to be that the Missippi will break through a tongue of land and throw a volume of its ter into the Atchafalaya; but I asked him the question the day ore I left Washington if there was any erosion on the west bank of Mississippi, and he said not that he knew of.

The WITNESS. There is very little or none.

Q. Now, where have you put in those sill dams—down near Simsrt?—A. Yes, sir.

Mr. VEST. Where is that tongue of land that Senator Caffery thinks Mississippi may break through?

The WITNESS. I can not imagine, sir.

Q. I would be glad to have your views upon the revetment and conaction system.—A. I will speak particularly of the character and antity of revetment work that the commission has been engaged on for the past two or three years, since they submitted estimates to ngress concerning the continuous revetment of the river. Since at time we have confined our work to three kinds of localities. We ve gone on with the revetment of harbors. We have done work at ckman, Columbus, New Madrid, Helena, Memphis, and so on down

the river. Those works have been entirely successful. Some of them still need extension. The work at New Madrid is entirely successful, but should be extended probably twice its present length. The same is true at Helena. And that is the only limit to their success—that there is not enough of them; and that is determined by the money, of course.

Mr. VEST. Have any of them given way?

The WITNESS. No, sir; not these small town harbors that I am speaking of now.

Q. You consider, then, in short, Major, that revetments are essential and useful, both in protecting so-called harbors on the river and also in protecting levee fronts from erosion?—A. I do not think it can be done, sir, in any other known way.

Q. And the only thing that militates against the system at all is the matter of expense—the cost of it?—A. I do not think the matter of cost militates against it in such localities.

Q. In limited localities?—A. In limited localities.

Q. But I mean as to its full adoption.—A. Yes, sir.

I would like to call attention particularly to the work at Memphis Harbor. When the commission first took charge of the river, the caving was on the left bank, or the Memphis side, above the city. That was reveted, and the revetment is successful, and there has been little or no trouble there since. The danger then was that the front of the city of Memphis would be caved in. That danger passed, and Memphis was then threatened with a subsequent danger.

Q. That of a cut-off?—No, sir; I do not think it was the danger of a cut-off. The recession of the upper side of Hopefield Point (which is on the right bank of the river) allowed the growth of the opposite bar on the left bank, which gradually extended down the river and threatened to close up the Memphis Harbor front. The only way to prevent that was to build the Hopefield revetment and prevent the further recession of that point, and we started at work to do that. Then came the restriction placed on us by Congress, and for two or three years we were forbidden to build any revetment work. During that time Hopefield Point continued to cave, and the bar on the opposite side to extend downstream, and Memphis lost irretrievably one-third of her harbor front. She never can regain it. It was lost during that time and for that reason. That is the history of revetment at Memphis. The revetment at Delta Point and Vicksburg Harbor is of equal importance to Vicksburg. If that revetment should fail or not be maintained, and the point travels down the river, Vicksburg will, to a certain extent, share the fate of other towns whose fronts have been covered by bars; at any rate, the work of the maintenance of the Yazoo Canal will be very much increased.

Q. In your opinion, then, Major, to sum up, revetments (expense or no expense) are necessary and essential and must be resorted to in cases like these at Memphis, New Madrid, Vicksburg, and other points similarly situated?—A. Yes, sir.

Q. And also in cases where it is essential to protect levees from immediate destruction near bends?—A. Yes, sir. Also where your line of levee is between the river and an old lake, for instance, and also for the prevention of cut-offs. Those objects can be accomplished in no other way.

Q. And, without going into the subject of revetments in general, you believe in supplementing the levee system with such work to the extent you have indicated?—A. I do.

Mr. VEST. Major, how is this revetment made?

The WITNESS. It is made of willow brush bound in fascines, the ndles being about 15 inches in diameter. These bunches are bound gether until they get a length of 1,000 or 1,500 feet and a width of) feet; that gives you an area of 8 or 9 acres afloat of this stuff. en stones are put upon it and it is sunk into the bed of the river. en the bank above low water is graded to a slope of about one on ır, and that is riprapped with stone. None of this work which is built mattress work is exposed even at low water.

U. S. S. MISSISSIPPI, *February 6, 1898.*

HENRY B. RICHARDSON, sworn, testified as follows:

Examined by Mr. NELSON:

Q. Where do you live, Mr. Richardson?—A. In New Orleans.

Q. What position do you now occupy?—A. Chief engineer of the ate of Louisiana.

Q. With jurisdiction over what?—A. Over the works of Louisiana, arge part of which works are the levees.

Q. As State engineer you have authority over and charge of the tire levee system of the State?—A. Yes, sir.

Q. How long have you held the position that you now hold?—A. nce 1880.

Q. You are head engineer, having charge of all the public works of e State?—A. Yes, sir.

Q. Will you please state how the administration of your levee system Louisiana is carried on; in whose hands it is, by whom it is managed, :. You might state, first, the number of districts, and then state the ministration.—A. There are now in the State of Louisiana twelve vee districts, each of which is supposed to be a territory to some tent topographically independent of the other districts.

Q. Can you state from memory what each of these districts is?—A. the upper portion of the State there is the Fifth Louisiana district.

Q. What does that comprise?—A. That comprises, in general terms, e territory between the Mississippi River and the Tensas and Mason, d from the Louisiana line to the mouth of the Red River.

Q. Does this district that you have described include what the Gov- ıment engineers understand as the whole Tensas Basin, from the 'kansas to the mouth of the Red River?—A. It does not include the ıole of it. It includes all except the portion in the State of Arkansas.

Q. So that the district you have described includes all the Tensas ısin front in Louisiana?—A. Yes, sir.

Q. Now, go on with your enumeration of the districts.—A. South of e mouth of Red River, on the right bank, comes the Atchafalaya Basin vee district, which, so far as its front is concerned, is the same as the ississippi River Commission's Atchafalaya district.

Q. That includes the Mississippi River from the mouth of the Red iver to what point?—A. To Bayou Lafourche. Donaldsonville is at e head of Bayou Lafourche.

Q. And in that district you have both the Atchafalaya, Bayou Teche, ıd Bayou Plaquemine. Are those all in the district?—A. They are l in the district. It is generally bounded by the Atchafalaya and the che on one side and by Bayou Lafourche and the Mississippi River the other.

South of the Atchafalaya Basin levee district (on the right bank still) is the Lafourche Basin levee district, which extends from Bayou Lafourche to a point fifty odd miles below New Orleans.

Q. That includes, in addition to the Mississippi front, also the Bayou Lafourche?—A. The Bayou Lafourche. South of the Lafourche Basin levee district still in the Buras levee district, extending from the point last named to the jump.

Q. That is right above the passes?—A. About 11 miles above the head of the passes.

On the left bank we have the Pontchartrain levee district, extending from Baton Rouge to the upper limits of the city of New Orleans. Then we have the Orleans levee district, which includes the city of New Orleans on both sides of the river. Then we have the Lake Borgne Basin levee district, extending from New Orleans to Bohemia Plantation, about 50 miles below New Orleans. There is, also, an organized levee district that has never done any work, called the Cat Island levee district, which is just above Bayou Sara. We have beside that several levee districts on Red River.

[See map marked "Exhibit W," appended.]

Q. For each of these levee districts you have a separate levee board?—A. For each of these levee districts there is a board of levee commissioners.

Q. How many?—A. They differ in number from three to ten.

Q. Has each board an engineer of its own, or are you the engineer for all of them?—A. The board of State engineers are exofficio engineers for all of the districts of the State except the Orleans district. The State board of engineers consists of five members.

Q. Of which you are the head?—A. Of which I am the head.

Q. And that board constitutes the engineering force for all the districts?—A. Yes, sir; except the city of New Orleans.

Q. Will you please prepare and send me a paper (and we will attach it to your testimony) giving the mileage of levees on the Mississippi River within your State, and also a statement of what your State has expended in the construction of levees on the Mississippi River since the war?

[See papers marked "Exhibits W, X, Y, and Z," appended.]

A. I will do so. Possibly I could give you the length of front on the Mississippi River now. The Fifth Louisiana district is about 246 miles in length; the Atchafalaya Basin levee district is about 130 miles.

Q. On the Mississippi River?—A. All of these are on the Mississippi River. The La Fourche Basin levee district is about 120 miles in length, and below that is the Buras levee district, having a length of about 34 miles.

Q. The districts you have named include all the mileage in your State on the Mississippi River?—A. On the right bank.

Q. Now give us the left bank.—A. The Pontchartrain district about 126 miles; the New Orleans district 26 miles on both sides of the river—about 13 miles on each side.

Q. And below that?—A. The Lake Borgne Basin levee district, with a front of about 48 miles. Below the Lake Borgne levee district the public levee system, in charge of parochial authorities, extends to Fort St. Philip—about 23 miles.

Q. Are you able to tell us how much your State has expended?—A. I am unable to separate expenditures for levee work on the Mississippi River from total expenditures for levees on all streams for years previous to 1879; but the total cost of levees built by the State and levee dis-

ıe Mississippi River and interior streams from 1865 to 1898
5,712.51. From 1879 to 1898 the cost of levee work under-
ıe Mississippi River by the State and levee districts has been
16.
ement marked "Exhibit X" appended.]
is the total amount expended by your State?—A. It is the
nt paid for actual levee construction by the State and levee
uring the periods stated, so far as they are recorded in the
f the State engineer department, but it does not include
a very large amount of levee work done (mostly before the
vee districts were incorporated) by parochial and municipal
, nor the expenses of administration, nor the interest and dis-
l by some of the levee districts on their bonds and other
is also exclusive of the cost of most of the wooden revet-
l other more or less perishable and temporary protective
well as of all "high-water expenses," such as guards, emer-
r, sacks, lumber, freight, etc. In short, it practically includes
ıt the cost of earthwork, mostly done under contract. The
represented by these expenditures amounts to 81,428,947
ls since 1865, on all streams, while on the Mississippi River
e the beginning of 1879, it amounts to 40,743,915 cubic yards.
t was the average cost of that per yard?—A. On all streams,
about 27 cents per cubic yard, and on the Mississippi River,
, nearly 19 cents per cubic yard.
he average?—A. Yes, sir. Of recent years the cost has
. less.
us approximately what has been the average cost during
ıw years.—A. The average price of work done by the State
districts from April 20, 1892, to April 20, 1894, was 17.57
ubic yard. The average cost of all levee work done by the
levee districts from April 20, 1894, to April 20, 1896, was
ı per cubic yard.
ıs been coming down?—A. It has been coming down. The
rice of work done by the State directly during the latter
ı 10.54 cents; that done by all the districts of the State was
l.
is State you work your convicts on the levees, do you not?—
ts work on the levees; yes, sir; under contractors.
let your convicts out to contractors?—A. The State of
leases its penitentiary to a firm who are in the contracting
They bid as any other contractors.
under contractors is the only way in which your convicts
That is the only way.
State does not use them directly?—A. The State does not
lirectly.
e levee building in your State carried on by contract work
A. Almost entirely by contract. I may say entirely by con-
ll levee construction, though sometimes repairs are made by
t levee boards with day labor.
can you give us some idea of the average height of your
n New Orleans up?—A. I should think the average height
e, along the Mississippi River above New Orleans, is over 12
table marked "Exhibit Y," appended.]
are familiar with the flood stages of the floods prior to 1897,
down?—A. Yes.
were the flood stages within your State in 1897, as shown by

the gauges, as compared with prior years?—A. The 1897 flood heights on the Mississippi River and the outlet bayous exceeded anything that has ever been before recorded.

Q. About how much on an average? Take the highest point of the 1897 flood and compare it with the highest point of any previous flood, what was the average excess in 1897?—A. I would make a guess that it was a foot and a half or perhaps two feet. It was something over three feet toward the upper end, and it was less than a foot in some places at the lower end.

Q. It varied from a foot to three feet?—A. It varied somewhere from a foot or a little less at the lower end to nearly three and a half feet at Vicksburg, toward the upper end.

Q. If you have stations on the Mississippi River you might give us the excess of the flood of 1897, over other floods, at each of those points.—A. At Lake Providence (which would be in the upper part of the State) 2.4 feet; at Vicksburg, 3.45 feet; at St. Joseph (which we passed a little while ago), 2.55 feet; at Natchez, 1.2 feet; at Red River Landing, 1.33 feet; at Bayou Sara, 1.55 feet; at Baton Rouge, 2.2 feet; at Plaquemine, 2.45 feet; at Donaldsonville, 2.2 feet; at College Point, 2.05 feet; at Carrollton, 1.55 feet; at New Orleans, 1.6 feet; at Fort Jackson, 0.3 foot.

Q. It runs, then, from about a foot to three and a half feet, does it not, from New Orleans up?—A. From 1.6 feet at New Orleans to, say, 3.45 at Vicksburg.

Q. From one and a half to three and a half, could you say?—A. About that.

Q. The average would be about two?—A. The average, I think, is something like two.

Q. Did many crevasses occur within your State, on the Mississippi River, in the 1897 flood?—A. There were three crevasses on the Mississippi which were not closed during the flood.

Q. What were those three?—A. Biggs crevasse——

Q. Biggs crevasse was near Vicksburg?—A. About five miles below Vicksburg; the Reed crevasse, within a mile and a half of it. The Biggs and Reed crevasses occurred within one day of each other.

Q. Where was the third?—A. The Glasscock Island crevasse, below Natchez.

Q. Those were not closed?—A. They were not closed during the flood.

Q. Can you remember the length of those respective crevasses?—A. I believe the Biggs crevasse was 2,500 feet in length. The Reed crevasse was about 1,100 feet in length. The length of the Glasscock crevasse I do not remember.

Q. Then you had some crevasses that were closed pending the flood?—A. Yes. There was a crevasse at Conrad Point, below Baton Rouge, that occurred after the water had declined 2 feet, or something like that, which was promptly closed. Besides that, there were several other crevasses in the lower part of the river in the Buras levee district, which were closed.

Q. You are familiar with the fact, of course, that the flood gauge at Cairo in 1897 was not quite as high as in 1882 and 1883, but it was higher than some of the other floods?—A. Yes, sir.

Q. And yet with you the gauge was higher, as you have stated. Now, how do you account for that difference in the height of the water down here? To what causes do you ascribe it?—A. I think it partially due to the improvement and increase of levees.

Q. The building of more levees?—A. The building of more levees, the better control of the floods above.

Q. The increased construction of levees, and the inclosure of more river basins above?—A. And in the lower part of the river I am disposed to attribute it to what I regard as probably the silting up of the river during the several years of comparatively low water.

Q. You think that the river bed, during some years, has been gradually rising a little?—A. No, sir.

Prior to the flood of 1897?—A. I do not think there has been any progressive rising.

Q. I mean, do you think that, owing to the low stages that prevailed for some years prior to the flood of 1897, there had been a raising in the bed of the river?—A. That is my belief; that during the years when the floods were not great, there was probably a deposit of material in the bed of the river in the lower part of its course, where it always remains a comparatively deep pool during the low-water period.

Q. A deposit that was not carried off?—A. Which was only removed by the flood of 1897, but not before the flood came.

Q. And you think that had some bearing on the flood of 1897?—A. I believe such deposits may have temporarily obstructed the channel and reduced its capacity for discharge until higher stages and stronger currents removed them.

Q. Have you any idea as to about how much of a figure that would cut?—A. I have not.

Q. What effect has the continuation of the levee system and the inclosure of those several basins above had upon the channel of the river, in your opinion?—A. I believe that the tendency of confining the water is to scour out and enlarge the channel and make a better channel for discharge—probably a deeper one.

Q. On the whole, then, it is your opinion that the rise of the water in the flood of 1897 occurred not so much from any general filling up of the bed of the river as from the increased construction of levees and the inclosure of other basins?—A. That is my belief.

Q. About how much would your levees require to be fortified, on an average, above their present condition to make them perfectly safe to withstand such a flood as that of 1897 proved to be?—A. I am disposed to think between 3 and 4 feet, as to the State of Louisiana.

Q. You would need from 3 to 4 feet higher levee on an average?—A. Than we now have.

Q. To meet the exigencies of such a flood as the flood of 1897?—A. I think so.

Q. And to be perfectly safe?—A. That is of course an off-hand opinion.

Q. Do you take into consideration, in giving that opinion, the complete closure of all the basins above and the perfection of the levee system?—A. I have that in mind; yes, sir.

Q. It is on that theory that you think, if the levee system is completed, you will require from 3 to 4 feet higher levee, and, of course, to fortify in proportion?—A. Yes, sir. I think many portions of the levee system of Louisiana need strengthening; that even for the height they now have they need a greater width of base.

Q. Do I understand the law in your State is that the riparian owners have to give the right of way for the levees free?—A. The law of Louisiana is well settled in that respect; it has come down from the French and Spanish occupation.

Q. Under your law is the State at liberty to take any land you need

for levee purposes and the earth for the construction of the same without paying any damages?—A. Yes, sir. Within the past eight or ten years a number of suits have been brought, covering almost all phases of that question, and the jurisprudence seems to be very well settled by the State, and the holding of the State courts has been affirmed by the Supreme Court of the United States, so I am told.

Q. As to your State?—A. As to the State of Louisiana.

Q. Have any suits been brought (involving not the question of damages for right of way—that is, for the land taken for the construction of levees—nor for the land left outside, between the levee and the river) to recover damages because their land was flooded on account of the insufficiency of the levee or the improper construction of it, or anything of that kind?—A. I know of none.

Q. The suits that have been brought, then, have related merely to claims for compensation for the land taken for levees and for land left outside?—A. Yes, sir; for immediate damage done by the construction of levees.

Q. And for damages by leaving land outside?—A. Or for the taking of property without compensation.

Q. If it were submitted to you by the General Government, what suggestions or recommendations would you make as to levee improvements in your State?—A. I would recommend that sufficient sums be appropriated to very greatly enlarge the present levee system, and that they be made available in large sums or for a long period of time. As to the levee system itself, I do not suppose I need say that I believe it is the only means of protecting this country from overflow.

Q. If you had ample funds, how long would it take you, under reasonable conditions, to bring your levees up to that higher state of 3 to 4 feet, as you suggest?—A. I believe that could be done in three or four years in the State of Louisiana; perhaps less.

Q. Would your people be willing to put the Mississippi River levees under the jurisdiction of the Federal Government, do you think?—A. So far as I can judge of the temper and spirit of the people of Louisiana, I think that would be the wish of ninety-nine out of a hundred.

Q. And would they be willing to do that if the Federal Government contributed half and they contributed half to the construction and maintenance of the levees?—A. I am disposed to think so, though their willingness, or rather their ability, to do so, or to continue expenditures for levees at the rate they have been incurred for the past five or ten years may be questionable. The levee districts are taxed for levee purposes probably about as much as it is practicable to collect. Most of them have considerable bonded debts (over $3,000,000 in aggregate) for which sinking funds must sooner or later be provided. This, with the accruing interest (6 per cent), will absorb a large share of their future revenues and leave them without resources to undertake work on the scale they have been carrying it on for a few years past.

(See table marked "Exhibit Z," appended.)

Q. That is what I mean.—A. No, sir; that never has been done. I am not aware that anything has ever been done except that a few hundred dollars was given by one of the levee boards to try some kind of a spur dike—which was a failure, by the way. I believe they hold that they have a right to do it, but it never has come within their means.

Q. They never have done that to protect their levees?—A. No, sir.

Q. Your course has been, then, where a levee has been threatened

and in imminent danger, on bends of rivers, etc., to build new levees inside?—A. To go back and build another levee.

Q. Have you any idea of the cost of the maintenance of your levees (and by that I include the cost of putting in new levees where older ones are threatened by the river)? What does it cost you annually to maintain your levees, including the rebuilding of portions that have been replaced?—A. I could not give a statement of what it has cost in that way. It would hardly convey any idea, in my judgment, as to what it should cost in the future.

Q. Give us your best judgment of the cost of maintenance and what you would include in that. State your opinion of the cost of maintenance as compared with Major Harrod's opinion, in respect to Louisiana.—A. I think Major Harrod's estimate was 2½ per cent, if I understood him rightly.

Q. Yes, sir; for the whole reach to Cairo.—A. I think that would be too much for the State of Louisiana, principally for the reason that all the lower part of Louisiana does not require such frequent renewals of levees. The erosion of banks is not so rapid. It has frequently happened in the upper portion of Louisiana that five or six hundred feet of the bank has been lost by caving in a single year. One-quarter of that would be very excessive in the lower part of the State.

Q. Take the reach of the river from the mouth of the Red River up; to what extent have you suffered from erosion or the undermining of levees by the river—where the river has worked in and undermined the bank, and so rendered your levees useless?—A. A very large proportion of the levee building previous to, say, ten years ago was required in consequence of the caving of banks. Since that time the work done by the General Government has added very largely to the means for building levees; they have, hence, been better located; they have been located farther back from the caving banks.

Q. The great damage you sustained before arose from defective locations of your old levees, did it not?—A. That was the greatest difficulty.

Q. The levees were built too close to the bank?—A. Yes. There was not means to do more than to make what you might call a temporary patch of levee.

Q. And close to the river?—A. Comparatively close.

Q. Too close?—A. Very frequently too close.

Q. And the great advantage of the Federal system has been that you have been enabled to get a better location?—A. Yes, sir; not only because of having larger sums of money has the work of the Federal Government made better levees, but it has left less for the people in the districts to do, and consequently the levees can be located on better lines, farther back.

Q. From Red River down to New Orleans you have not had so much trouble, have you?—A. No.

Q. The river is more settled in its channel?—A. The banks cave less rapidly.

Q. And there are less curves in the river, are there not?—A. Rather less curves in the river.

Q. Do you know Mr. E. T. King, statistician of the parish of the Teche?—A. I know a Mr. King; I do not know that I know this Mr. King..

Q. He signs himself, "Statistician, parish of the Teche."—A. I can not say that I do know Mr. King; I think I have met him.

Q. I want to read you a statement that he makes, and ask your opinion on the subject:

There is another danger threatening our people, and that is the danger of the Mississippi River going down the Atchafalaya, which has, during the flood of last spring (that means 1897), proved its capacity to overflow nearly the whole basin without a break in the line of levees from the mouth of the Red to the railroad crossing on the Lafourche. The distance is only one-third of its present channel, the fall much greater, and the only reason it does not now take to that route is that the Atchafalaya is not wide and deep enough to discharge such an immense volume of water, but it is both widening and deepening rapidly, and it is only a question of time when it will be large enough and the whole Mississippi River discharge itself in this direction. The result will be to flood five and jeopardize as many more of the richest parishes in the State. The remedy is to entirely divorce the Red and Atchafalaya from the Mississippi. Nature has been trying to do this for years. But the United States Government has been spending nearly a million dollars in dredging out the sandbars and mud flats in Old River, that nature had placed there, for the purpose of keeping up navigation with the Red and Atchafalaya. As soon as the locks at the Plaquemine are completed there will be no necessity for this, as there will be a certain and safe communication at all times through these locks, and no necessity for keeping open Old River. Then it can be easily closed and all danger of the Mississippi River coming in this direction prevented. It will not only do this, it will reclaim and protect from overflow 1,000,000 acres of the richest land in the world, lying in the Atchafalaya Basin and the parishes of Concordia and Catahoula, that is now worthless, and make them as valuable as any in the State.

Now, do you think there is any immediate or pressing danger of the Mississippi River breaking into the Atchafalaya?—A. I have never thought there was any great danger of the Mississippi River breaking into the Atchafalaya. And whatever danger there may have been I believe is fully controlled by the works of the Mississippi River Commission at Simmsport.

Q. You think they have accomplished whatever is necessary?—A. My belief is that they have accomplished whatever is necessary to prevent the enlargement of the Atchafalaya River. The old river itself, so far as I am aware, never has enlarged to any extent; it has a better channel for navigation than it formerly had, but is much narrower.

Q. Do you believe, as Mr. King intimates, that it would be advisable to divert the Red River wholly into the Atchafalaya, and make it one continuous stream, and cut it off from the Mississippi?—A. If all the levees along the Tensas Basin front were really in condition to be absolutely impregnable, I should think it would be greatly to the interest of a large part of Louisiana to have the Red and the Atchafalaya treated as one system, and the Mississippi as another; that is, to have them "divorced."

Q. And to have the Red River discharge into the Atchafalaya?—A. Yes, sir. But to-day, if I had the power to do it, I should fear to do it. I would not dare to do it while the levees above remain in their present imperfect condition. No one would, I suppose, without much more study of it, as an intricate problem, than has yet been given to it. My fear would be that breaks in the levees of the Tensas Basin——

Q. On the Mississippi, do you mean?—A. On the Mississippi. That the breaking of these levees would so fill up that basin that it would be very much more deeply overflowed than it ever can be while open at the lower end as it is now. Of course, when we have extensive breaks in the levees on the Tensas Basin front, water returns to the Mississippi River through Old River.

Q. Yes, but if you relieve the Mississippi River of the waters of the Red River, and divert them wholly into the Atchafalaya, how could that increase the danger up here on the Tensas Basin?—A. In the

esent condition of affairs all the waters of Red River usually go down, may go down, the Atchafalaya River.

Q. Under present conditions?—A. Under present conditions. In her words, the Atchafalaya is capable of carrying more than the Red ver proper ever brings down to it.

Q. Well, without a gread deal more levee work on the Atchafalaya, uld it carry the waters of the Red River complete, in addition to at it is now carrying?—A. I think it could not in the Lower Atchalaya. The Lower Atchafalaya spreads out into a series of bayous d passes through a lake, the topography of which I am not very miliar with. I do not think it would be an easy matter to control the chafalaya River by levees when the Red is in flood, if the crevasse ter from the Tensas Basin were also carried down through the Atchalaya.

Q. But waiving all that, if you could divert the entire waters of the d River into the Atchafalaya and away from the Mississippi, would not relieve the Tensas Basin above here? Up above the mouth of the d River, would it not relieve the Mississippi?—A. It would, so long all Mississippi River water were excluded from that basin.

Q. I meant that it was excluded.—A. But if there were breaks in the ees, then the condition of that district would be very much worse an it is now, I apprehend, because the Atchafalaya itself would not en be large enough to carry the combined volume of a flood in Red ver and the water coming from the various crevasses that you can nceive of as possibly existing in the levees of the Tensas front.

Q. Would you regard it as wise to utilize the Atchafalaya to carry the surplus water of the Red, and also of the Mississippi water, in nes of flood? Would you think that would be a help below the mouth the Red River?—A. I think it would have some effect.

Q. Do you think it would do any good, without jeopardizing the ssissippi below the mouth of the Red River?—A. Possibly I do not derstand you.

Q. I mean, if you were to use the Atchafalaya by diverting into it not ly the Red River but a portion of the Mississippi at flood tide—— That is the condition now, is it not? As I understand it, that is the esent condition.

Q. Yes; but I mean, could it not be utilized still more extensively and ord relief to the Mississippi River below without jeopardizing the erests of the Mississippi River below the mouth of the Red River?— I should fear not. The difficulty of controlling it would be still eater than it is now.

Examined by Mr. CATCHINGS:

Q. What is the volume of discharge from the Mississippi now, in times flood, down the Atchafalaya?—A. I do not think I could tell you actly. It depends entirely upon what Red River does.

Q. But it is an enormous outlet in times of flood?—A. Yes; I suppose re than one-third, or nearly one-half, of the capacity of the Atchalaya is devoted to carrying out Mississippi water in times of flood.

Q. I understand you to say now, with the Atchafalaya as it is, onelf of its carrying capacity is devoted to transporting the Mississippi ods?—A. Yes, sir.

Q. Now, I understood you to say, Major, that you would not divorce e Atchafalaya and the Red from the Mississippi, if you had the power, the reason that while the Atchafalaya is ample to carry off the flood

waters of the Red, if it had no other burden to carry, yet, if crevasses occurred above the mouth of Red River, such a volume of water might go through those crevasses into Red River as, added to the volume of the Red River, would inundate all that lower country.—A. That is what I meant, but you have expressed it much better than I did.

Q. But you would not incur that danger if you had the power?—A. I would not dare do it in the present condition of the levee system on the Mississippi River front of the Tensas Basin.

Examined by Mr. NELSON:

Q. Assuming that the levees on the Mississippi River from the mouth of the Old River, up on the Tensas front were sufficient so as to be safe, would you then believe it a proper thing to divert the Red River into the Atchafalaya as a means of protecting against floods below the mouth of the Red River?—A. I should think it a very desirable thing for those people who live down on the Teche and all that country.

Q. To divert the Red River down there?—A. In my view of the situation Red River already runs down the Atchafalaya without diversion from its usual natural course; to divorce the two river systems (if there were no danger of crevasses) I think would be desirable. But that fact—the danger of crevasses—is of great importance.

Q. You mean if there were no crevasses above here?—A. Yes, sir; if there were a range of hills, for instance, along the bank of the Mississippi River, above any possible overflow, without gaps or openings in it, extending from and along the Arkansas River to the Red, instead of the existing imperfect line of levees, I should have little doubt as to the desirability of divorcing the Mississippi from the Red and Atchafalaya at the earliest moment practicable.

Examined by Mr. CATCHINGS:

Q. The Red River, as I understand, has a very large and valuable commerce, and boats now engaged in that commerce come out of the Red River into the Mississippi; and, in going from below up into the Red, they pass up the Mississippi, around Turnbull Island, and up into the Red. Now, if the Red were divorced from the Mississippi into the Atchafalaya, the only way that commerce could be carried on would be to go through the locks which we are building at Plaquemine, and then work up the Atchafalaya. Now, what effect would it have in the course of time upon the navigation, commercial, and steamboat interests of the Mississippi River, if they were compelled to go down and take that devious, long route?—A. I do not know how greatly, but it would to some extent, of course—at least during high water—increase the time and difficulty of navigation into Red River. The route to the Teche, Courtableau, and Lower Atchafalaya, however, would be shortened.

Q. Do you think the steamboat interests would consent to that divorcement?—A. My impression is that some of them would not favor it.

Examined by Mr. NELSON:

Q. What proportion of the water that goes into the Atchafalaya comes from the Red River and what proportion comes from the Mississippi, in your opinion, at high water, during flood stages?—A. I suppose a little more than half of it comes from the Red.

Q. And the other half from the Mississippi?—A. Less than half from the Mississippi; a little more than half from the Red, perhaps.

Q. As a stream, the Atchafalaya carries more water, does it not, or as much, as the Red does?—A. When full it carries more than the Red River proper ever could carry.

Q. Its capacity is greater as a water-carrying stream than that of the Red River?—A. Yes, sir.

Q. So that if the Mississippi water should be entirely excluded from the Atchafalaya and the Atchafalaya remitted wholly to the water of the Red, it would not have as much water to carry as it does where it takes water out of both streams?—A. No, sir; not as much.

Q. What is your opinion with respect to relieving the Mississippi River below by means of outlets through the Atchafalaya, the Plaquemine, and the Bayou La Fourche?—A. I think if it were successful in lowering the flood levels (which, by the way, I doubt) it would be a very expensive method of doing it. If any natural streams could be used for an outlet they would have to be leveed.

Q. Are there any other outlets of any consequence that you can think of besides the Atchafalaya, the Plaquemine, and the La Fourche?—A. Artificial outlets have been proposed frequently at various points. One of those is in the neighborhood of Bonnet Carre, another some 10 miles below New Orleans into Lake Borgne.

Q. Well, that is on the other side, is it not?—A. I thought you meant to take the river as a whole. Do you refer entirely to the right bank?

Q. I did. Now, are there any places on the left bank, below Baton Rouge, where the river could be relieved by outlets?—A. On the left bank outlets are often spoken of at Bonnet Carre, at Pass Manchac, and into Lake Borgne.

Q. Pass Manchac, into the Amite River?—A. There was a natural outlet there at one time. It was long since closed.

Q. The Amite River flows into Pontchartrain, does it not?—A. Yes, sir. I think any relief that could be produced by opening Bayou Manchac would be utterly insignificant, as you may see if you land there and look at it, and it would be necessary to levee its banks for many miles.

Q. That outlet would go into the Comite and from thence into the Amite, would it not?—A. I believe it would go into the Amite and thence into Lake Pontchartrain.

Q. Are there any other points below there where you could make outlets that would be of any utility?—A. I do not think there are.

Q. Are there any points there where an outlet could be made into Lake Pontchartrain?—A. Bonnet Carre has often been spoken of, where a crevasse existed for nine or ten years; the water came through there at high stages of the river, when it got over its banks, ran into Lake Pontchartrain and produced great masses of deposit, drift, and sand; in other words, it began to silt itself up, which caused the effluent water to spread out and overflow the country more and more until the crevasse was closed in the winter of 1882–83.

Q. The river did, at high stages, make use of that outlet to some extent then?—A. For eight or nine years.

Q. Did it serve as a relief to the country below?—A. I think not to any considerable extent.

Q. You would not, then, on the whole, as I understand it, be in favor of utilizing any of these outlets?—A. No, sir.

Q. As a means of relief?—A. I think not. I think there is but one method of protecting the country from overflow, and that is by means of levees.

Major HARROD. I spoke with Major Starling and Captain Dabney yesterday on the subject of the cost of maintenance, and gave them my methods and results, and I understood them to agree with me substantially.

Mr. RICHARDSON. I would like to add a word as to my reasons for thinking Major Harrod's estimate of the cost of maintenance of levees may be excessive so far as Louisiana is concerned.

As I understand it, his estimate is based upon an assumption that the levee lines are located along concave bends, adjacent to about half the total length of the levee line, where erosion is going on, at such a distance from the bank that they must be renewed, on account of the recession of the bank, every twenty years, equivalent to a renewal of the whole line once in forty years, so that, on an average, 2½ per cent of the line must be renewed annually. It also assumes that the cost of levee work per unit of length will remain the same hereafter as that now estimated for the work of construction. Both these assumptions, it seem to me, may be reasonably modified in a direction to give a smaller result.

While the Mississippi River Commission expects its levees to be so located as to last at least twenty years, locations that may last much longer are not prohibited, and, in my judgment, the general line of levees in Louisiana along concave bends may be expected to last, on an average, much more than twenty years, especially the line of levees below the mouth of Red River. Twenty-five or thirty years appears to me a fairer estimate for Louisiana, notwithstanding the fact that the upper end of the State has about 150 miles of the most excessively caving bank to be found anywhere along the entire course of the river.

Again, the cost of levee work per cubic yard has already been greatly reduced by the larger amount of work offered, by improved methods and machinery, and by closer economy. There is no apparent reason to my mind why still furthur reductions may not come as the work continues. Whenever a system of levees of sufficient height and section is once completed the repairs and renewals necessary for maintenance should constitute a class of work that can be long foreseen and which need only be undertaken under the most favorable conditions that can be selected; not, as now, in the inevitable hurry of active construction on short time, often in the most unsuitable season, and sometimes with doubtful prospects as to the time and certainty of payment. Such work may reasonably be expected to be done at less prices than those estimated for the work of construction. If the work of construction is estimated at 15 cents per yard it seems to me fair to estimate the work of renewal at not over 12 cents.

And, finally, I am not without hope that the caving river banks will in time be revetted and held in fixed position. Wherever they are so held the work of maintaining levees should be reduced almost to the simple care of the grass growing on them, and the minor repairs called for by occasional wave wash and rain wash, with such guarding and inspection as ordinary prudence demands for the preservation of any public work.

I will send from New Orleans at an early day statements, tables, etc., relative to levees in Louisiana, and request that they be attached to and form a part of this testimony.

[See the following papers, marked "Exhibits W, X, Y, and Z."]

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EXHIBIT X.

OFFICE BOARD STATE ENGINEERS OF LOUISIANA,
New Orleans, February 20, 1898.

Statement showing amount and cost of levee work undertaken by the State of Louisiana and its several district levee boards from 1865 to February, 1898, condensed from Appendix C, report board of State engineers of April 20, 1892, with additions from later reports and records of the board of State engineers of Louisiana.

Periods.	Levees on the Mississippi River.		Levees on interior streams.		Totals for all streams.	
	Cubic yards of earthwork.	Cost.	Cubic yards of earthwork.	Cost.	Total cubic yards of earthwork.	Total cost.
1865 to 1879 *a*	19,674,878	$10,133,574.33	1,774,593	$1,127,279.22	21,449,471	$11,260,853.55
1879 to 1881, both inclusive *b*	3,254,110	707,277.08	132,154	34,473.55	3,386,264	741,750.63
1881 to February, 1898 *c*	37,489,815	6,991,928.08	19,103,397	2,941,180.25	56,593,212	9,933,108.33
Aggregate, 1879 to February, 1898, both inclusive	40,743,925	7,699,205.16	19,235,551	2,975,653,80	59,979,476	10,674,858.96
Aggregates for all streams, 1865 to February 20, 1898 *d*					81,428,947	21,935,712.51

Levee district.	Levees on the Mississippi River.		Levees on interior streams.		Total for all streams.	
	Cubic yards of earthwork.	Cost.	Cubic yards of earthwork.	Cost.	Total cubic yards of earthwork.	Total cost.
Kensas Basin	2,011,525	$443,954.29	86,499	$16,686.55	2,098,024	$460,640.84
Fifth Louisiana	13,774,463	2,553,075.07			13,774,463	2,553,075.07
Atchafalaya Basin	7,980,712	1,444,770.48	4,672,502	718,055.64	12,653,214	2,162,826.12
Lafourche Basin and Buras	5,813,511	997,118.41	3,609,069	486,919.45	9,422,580	1,484,037.86
Pontchartrain Basin and Lake Borgne	6,559,187	1,270,092.08			6,559,187	1,270,092.08
Orleans	1,350,417	282,917.75	469,610	135,079.17	1,820,027	417,996.92
Caddo			3,323,522	516,467.07	3,323,522	516,467.07
Bossier			2,566,834	370,743.34	2,566,834	370,743.34
Red River, Atchafalaya, and Bayou Bœuf			4,375,361	697,229.03	4,375,361	697,229.03
Total	37,489,815	6,991,928.08	19,103,397	2,941,180.25	56,593,212	9,933,108.33

a Amount and cost of levee work, 1866 to 1879, can not be accurately separated as to work done on the Mississippi River and on interior streams: but the records show that only a small proportion of the work was done on interior streams, and the above figures give the best information now available.

b The first work undertaken by the United States on the Mississippi River was in 1882.

c Amount and cost of levee work on Mississippi River and interior streams as above stated, distributed in the several levee districts as follows (1881 to February 1896):

d The above items are exclusive of the large and mostly unrecorded amount of work done on the public levees in Louisiana (the greater part previous to the organization of the levee districts) by parochial and municipal authorities, by corporations and private parties, and do not include any expenses of administration nor discount or interest paid by the several levee districts on bonds or other debts. They are also exclusive of most of the wooden revetments and other protective works and of all "high-water expenses," such as sacks, lumber, freight, guards, laborers, etc.

EXHIBIT Y.

STATE OF LOUISIANA, OFFICE BOARD OF STATE ENGINEERS,
New Orleans, February 17, 1898.

Table of approximate mean dimensions, length, and contents of levees on the Mississippi River in the several levee districts of the State of Louisiana, including work now under contract and expected to be in position by June, 1898.

District.	Length of levee line in miles.	Average height of crest above high water of 1897.	High water of 1897 above highest previously recorded water.	Average height of levees.	Average width of crown.	Average side slopes.		Approximate contents.	Remarks.
						Land side.	River side.		
		Ft.	*Feet.*	*Ft.*	*Ft.*			*Cubic yds.*	
Fifth Louisiana ...	221	2	3.5 to 1.2	11.6	8±	3 to 1	3 to 1	23,040,752	Levees extend from the Arkansas line to Bougere Landing (26 miles below Bougere practically unleveed); contents given include about 1,504.618 cubic yards in banquettes.
Atchafalaya Basin.	128	3	1.3 to 2.5	13.3	8±	3 to 1	3 to 1	16,527,682	Levees extend from Barbre Landing at head of Atchafalaya River to Bayou Lafourche; contents given include about 194,558 cubic yards in banquettes.
Lafourche Basin...	120	2	2.2 to 1	10.8	6±	3 to 1	3 to 1	9,732,096	Levees extend from Bayou Lafourche to upper line of Orleans Parish, and from lower line of Orleans Parish to lower line of Riceland plantation.
Pontchartrain	126	2	2.5 to 1.5	11.4	6+	3 to 1	3 to 1	11,291,797	Levees extend from city limits of Baton Rouge to upper line of Orleans Parish.
Orleans	26	4	1.6	9.3	8±	3 to 1	3 to 1	1,700,000	Levees extend along entire front of Orleans Parish on both sides of the river.
Buras	34	1	1 to .3	4.3	5±	2 to 1	3 to 1	450,000	Levees extend from the lower line of Riceland plantation to the Jump.
Lake Borgne Basin.	48	2	1.6 to .3	8.3	6+	3 to 1	3 to 1	2,407,153	Levees extend from lower line of city of New Orleans to lower line of Bohemia plantation.
Left bank below Lake Borgne Basin.	23	....	.3	3	2±	1½ to 1	1½ to 1	87,700	Levees extend from lower line of Bohemia plantation to Fort St. Philip.
Total	726	....	.....	....	....	.....	.....	65,237,180	

NOTE.—The total length of public levee line in the State of Louisiana on the Mississippi, Red, Ouachita, Black, Little, and Atchafalaya rivers, and on bayous Des Gloizes and Lafourche is estimated at 1,194 miles, containing, as estimated in June, 1897, about 86,000,000 cubic yards.

The State of Louisiana also depends for protection against overflow upon about 90 miles of levee line extending up the Mississippi River on Cypress Creek and Amos Bayou in Chicot and Desha counties, Ark.

New Orleans, La., February 20, 1898.

Resources of the State of Louisiana and the several levee districts of the State for levee purposes under existing laws, with estimated gross amounts of taxes and local assessments, based upon returns for 1897.

	Laws.	Amendments.	Bonds.		Mill tax.		Acreage, railroad, and produce assessments.				Gross annual revenues.
			Amount authorized.	Amount issued to date (N. O. Stock Exchange).	Rate permitted.	Gross amount (State auditor).	Rate permitted per acre.	Rate permitted per mile.	Gross amount acreage and railroad assessments (State auditor).	Produce assessment collected in 1897 (State auditor).	
					Mills.		*Cents.*				
From the State at large (i. e., the general engineer fund), distributed under act 102 of 1892, as follows:											
Orleans levee district $10,000.00											
Tensas Basin levee district (10 per cent) 20,359.82											
Caddo subdistrict (9½ per cent) 19,341.83											
Natchitoches subdistrict (3½ per cent) 7,125.94											
Other levee districts (77 per cent) 156,770.62											
Appropriations (act 26 of 1896). 46,200.00	No. 33 of 1879	(1)	.....	.....	1	$259,798.21	.....	.....	.....	.....	$259,798.21
REGULAR LEVEE DISTRICTS.											
Tensas Basin	No. 26 of 1884	(2)	$150,000	$149,000	10	11,559.85	5	$30–100	*a* $3,792.75	(*b*)	15,352.60
Fifth Louisiana	No. 44 of 1886	(3)	500,000	420,000	10	49,526.63	5	20–30–60	*c* 51,070.22	$37,704.60	138,301.45
Atchafalaya Basin	No. 97 of 1890	.....	1,000,000	800,000	10	127,217.88	2½	60	48,175.60	58,768.94	235,162.42
Lafourche Basin	No. 13 of 1892	(4)	500,000	250,000	10	86,027.82	2½	50–100	26,089.08	36,110.49	148,227.39
Buras	No. 18 of 1894	.....	10,000	.....	10	4,342.95	5	50	1,060.15	767.42	6,170.52
Cat Island	No. 10 of 1894	.....	100,000	.....	10	(*d*)	2½	100	(*d*)	(*d*)	.....
Pontchartrain	No. 95 of 1890	(5)	1,000,000	708,500	10	47,598.05	3	100	20,237.78	21,666.09	89,501.92
Orleans	No. 93 of 1890	(6)	.....	.....	1	140,822.64	.....	.....	(*b*)	(*b*)	140,822.64
Lake Borgne	No. 14 of 1892	.....	100,000	100,000	10	17,654.90	5	60	4,199.05	535.79	22,389.74
Caddo	No. 74 of 1892	(7)	200,000	199,800	10	6,456.80	5	60	*e* 5,383.50	6,173.80	18,014.10
Bossier	No. 89 of 1892	(8)	200,000	199,100	10	9,393.15	5	60	*e* 5,960.25	12,089.99	27,443.39
Red River, Atchafalaya, and Bayou Bœuf	No. 79 of 1890	(9)	250,000	250,000	10	30,397.10	5	60	22,631.45	(*b*)	53,028.55
			4,010,000	3,076,400	.....	790,795.98	.....	.....	188,599.83	174,817.12	1,154,212.93

NOTE.—Amendments to laws: (1) Acts 73 of 1882, 83 of 1884, 60 of 1886, and 102 of 1892; (2) 59 of 1886, 77 of 1888, and 70 of 1894; (3) 16 of 1890, 4 of 1892, and 48 of 1894; (4) 100 of 1892 and 19 and 175 of 1894; (5) 68 of 1892 and 59 of 1894; (6) 79 of 1892; (7) 90 of 1894; (8) 104 of 1894; (9) 46 of 1892.

a No acreage assessment made in 1897. *b* None authorized. *c* No railroad assessment made in 1897. *d* None assessed. *e* No railroad assessment returned.

Mr. Richardson joined in Exhibits H H and I I appended to the testimony of Major Harrod in regard to the passes.

U. S. S. MISSISSIPPI, *February 7, 1898.*

G. L. GILLESPIE, sworn, testified as follows:

Examined by Mr. NELSON:

Q. Colonel Gillespie, are you the president of the Mississippi River Commission?—A. I am.

Q. How long have you occupied that position?—A. Three years this month. I was appointed in February, 1895.

Q. Will you be kind enough to state to the committee, in your own way, the sources of the great floods of the Mississippi River, particularly the flood of 1897, and what you regard as the best means of repressing and restraining such floods and preventing their inundation of the country?—A. I do not know that I can add anything to the testimony of Professor Moore and others who have treated of the origin of the floods.

Q. The main source of the floods is from the Ohio, is it not?—A. Yes. That is shown by the discharge observations which have been taken under the direction of the local engineers and officers engaged on the improvement of those various streams (which are not included in the districts controlled by the Mississippi River Commission) and also by the discharge observations taken at the mouth of the Ohio and at Columbus.

Q. How did the flood of 1897 compare with the former great floods, in its high-water stages, in its duration, and in other respects?—A. The quantity of water, evidenced by the discharge observations taken at the several discharge stations under the Mississippi River Commission, shows no great difference from 1882; the volume was practically about the same, but the duration of the flood of 1897 was longer.

Q. And what, if any, was the difference in the stages of the flood on the river from Cairo down?—A. The water elevations varied very largely. The water elevation at Cairo was a little less in 1897 than in 1882, but when you pass below and get into the levee districts, the variations become very apparent. There was one very important gauge that showed the effect of these various oscillations, and that was the Helena gauge. At the beginning, say in 1882, when certain of the basins below were left open, the gauge at Helena varied from the one at Cairo by about 4½ feet, and between 1882 and 1897 it gradually rose until they came to almost an exact coincidence in reading, showing that the Helena gauge had risen about 4½ feet. We also found elevations of 3 feet or more at Vicksburg. I can not give you offhand the various elevations.

Q. Well, as a general rule, the flood stages from and including Helena, down the river, were much higher in 1897 than they had been at any previous flood, although the flood stages at Cairo were not higher?—A. Yes, sir.

Mr. BERRY. Colonel, do you think that the return water from the St. Francis Basin, coming out of the St. Francis River, just above Helena, aided in increasing the gauge at Helena?

The WITNESS. It undoubtedly did.

Q. To what causes do you ascribe the higher stages of water in the Mississippi River, from Cairo down, in 1897, as compared with the

stages of previous floods?—A. Of course there may be certain unknown causes, but the known causes (arguing from knowledge of hydraulics under similar circumstances) was levee construction, the confinement of the water within the adopted bed of the river.

Q. Increased levee construction and the closure of river basins was the chief cause?—A. That is my opinion.

Q. In your opinion, what effect has the closure of those basins and the building of those levees had upon the bed of the river, as to lowering or raising it?—A. That matter has been under consideration by myself for the past two years, but more particularly for the past four months, on account of the reference to me of a paper from the War Department in regard to certain allegations that had been made to the effect that the bed was rising, and I became convinced that the strength of the argument was on the side of the nonelevation of the depth and used the expression that I could affirm with great positiveness that, so far as I was able to determine, there was no appreciable progressive elevation of the bed, that is to say, no measurable increase.

Q. Taking your knowledge and experience of the flood of 1897, and prior floods, what would you suggest and recommend, as an engineer officer, for relief against such floods in the future?—A. I know of no practical means except the means provided by the building of adequate levees.

Q. What is your opinion as to whether any relief can be obtained in a reasonable and practicable manner by means of the reservoir system so called? And if relief could be obtained in that way, at what points would such reservoirs be feasible?—A. That question has also been very exhaustively treated by the commission. A very able and complete report was submitted by the commission at a time when I was not on the commission, and I accept their statements as a true presentation of the matter. I have not been able to locate in my own mind any place where a reservoir could be used with any prospect of affecting the river one way or the other. The matter is treated of by Humphreys and Abbot. They went into the Ohio Valley, and they found no place where they could catch the actual water that does the damage. There are plenty of places where you can get a reservoir effect, but in order to relieve the river you must catch and confine a certain amount of the water that comes into the bed of the river as a destructive agent.

Q. You are familiar with the reports that you refer to? Was any consideration given, that you know of, to the utilizing of any part of the St. Francis Basin for reservoir purposes?—A. That had not been directly presented to my mind until I joined your committee on this occasion.

Q. What are your views on that subject?—A. I have examined it as far as I have been able. In the first place, I do not see (even if you could properly conduct the water into the basin) how you are going to hold the water. There are no tying-on points. The dam or series of dams that would be necessary to be built in that basin to hold this water have no secure points for tying on—no high land. If you examine the western part of the basin it will be noticed that the St. Francis River will have to be crossed before you get to the high ground. The dam or series of dams would have to be at least 25 miles long, and in many places longer; and, when you come to the bank of the Mississippi River, you would have to tie on to an alluvial bank, and one difficulty or embarrassment that the constructing officer would meet is the unstable character of the foundation. The only known material of which you can build these dams would be earth. And, knowing the fall of the St.

Francis River (which is about a foot to the mile), if you build a single dam, it would have to be of enormous height, and the corresponding inclosing dams (one to follow the Mississippi River, and the other to follow the western side of the basin) would have to be built in corresponding dimensions, which would give rise to enormous expense, and I doubt whether, after all, you could hold the water in the basin. The seepage effect would be very large. I think it is reasonable to suppose, also, that the deposit in the reservoir would be rapid and progressive, and in a very short while would probably destroy the usefulness of any such area to be reserved for reservoir purposes, even if you could collect in the beginning a sufficient quantity of this escape water which produces, or is supposed to produce, this deleterious effect on the lower river. I think the whole scheme is impracticable.

Examined by Mr. BERRY:

Q. Colonel, even if it were possible to secure a holding ground there, would not the result be to overflow a large section of land that is now under cultivation in Lee, St. Francis, and Crittenden counties, and the counties there in Missouri?—A. It would necessarily overflow all areas that are below the level of your dam.

Q. And the expense of getting the water out, and the expense of holding it in, and the damage that would accrue to the citizens would be an enormous expense, would it not?—A. Yes, sir. Of course, in leading the water into the reservoir, you have to make provision for leading it out.

Q. What are your views as to the feasibility and propriety of constructing outlets to relieve the main river?—A. It must be remembered that before an outlet is constructed the engineer must know absolutely the amount of water that he wants to take out of the river. Therefore the dimensions of the outlet must be absolutely determined by calculation, and must be maintained—no more, no less. That requires that the water in passing out through the opening of this outlet shall be conducted with regard to the interests of the people over whose territory this conduit is made. If it is a stream of determinate area, it must be leveed if the banks are subject to be overflowed, and the bottom of the outlet must be studied, and, if it is one which can be easily eroded, provision must be made to prevent the erosion so as to maintain throughout the whole extent its cross-sectional area intact, preserving the property and lives of the people along the banks.

And after this outlet has been constructed, the ultimate point of delivery must be considered also. It must be determined whether the water will go directly into the Gulf, whether it would go through lakes or rivers, and whether it would change any existing conditions there. There is no point where an outlet can be considered at all except in the Atchafalaya direction or in that leading out into the Pontchartrain areas. We have in the first place Lake Pontchartrain itself, which is a navigable highway of considerable importance (especially in regard to the seaport of Mobile), has always been regarded as an important highway, and improvements have been made from time to time for the bettering of that highway. The Government of the United States in its wisdom from time to time has put up fortifications on this highway. Therefore it is an area that ought not be subjected to any deleterious influences, unless there is a greater demand for its use for other purposes. If the interests centering in the Mississippi Valley are greater than those interests that we conceive to be existing on the line between Mobile and New Orleans on all that water course, that would lead to

determination that the Mississippi River should be considered first. own impression is that there is no such interest there, even if it e practicable to use that outlet. I do not think you could conduct er enough off there at an expense that would be justifiable.

r. CATCHINGS. You spoke of the proposed basin up here being royed by deposits. Is it not very likely that a shallow lake like chartrain, Manchac. and all those shallow lakes would also become d up?

. Undoubtedly.

r. CATCHINGS. And cease to be an outlet?

. Yes, sir.

Examined by Mr. NELSON:

. I presume, Colonel Gillespie, that the only practicable points for et relief, if there would be any relief by such a system, would be Atchafalaya, Bayou Plaquemine, and Bayou Lafourche?—A. Yes, But the Plaquemine is now being improved, and you can eliminate ; for the present.

. It will be utilized if the improvement is completed?—A. It will tilized as a highway of commerce.

. And Bayou Lafourche?—A. Yes.

. Well, those outlets, even if it were feasible and practicable to ze them, could not in the nature of the case afford much relief in ie river above?—A. No, sir.

. Even if it were possible to make a greater use of the Atchafalaya outlet purposes, it could not afford any great relief in the Missis- i River above the mouth of the Red River?—A. I do not think it d.

. And the only relief that would be possible would be to the river w?—A. In the vicinity of the outlet, within a distance which has i variously calculated. It is hardly subject to exact determination, we know the influences of crevasses, and I suppose the influence of rge outlet would be felt somewhere between 40, 50, or 60 miles.

Examined by Mr. BERRY:

. Colonel, can you say with any degree of certainty, or is your d fully convinced, that if the St. Francis Basin had been closed in the guage would have shown any higher water at Helena, at ansas City, at Greenville, or at Vicksburg?—A. I do not think it ld have made any difference on the lower gauges. It certainly ld have given an elevation of the gauge reading at Helena due to e construction, but I do not know how anyone would be able to rmine the relative readings in the two cases. It would be simply atter of judgment, in my opinion.

. Have you fully determined that if the basin had been entirely ed and the water had all come down the main channel that the ge would have shown a higher mark at Helena than it did show n the return water from the St. Francis came down in contact with main flood and the two passed Helena together in that way?—A. ink that is a matter of judgment. I say there would be undoubt- , in my mind, an elevation of the gauge at Helena.

. You think there would have been?—A. Yes, sir; there would have i an elevation of the gauge due to levee construction. Whether ; elevation of the gauge would be higher than the reading given er the conditions which existed during the last flood I do not know ny way of determining, but my impression is that it would probably little higher with the basin closed.

Examined by Mr. NELSON:

Q. Colonel, as the levee system has been built up and more basins have been inclosed has not the tendency been to make the water higher in the river in times of high water?—A. Yes, sir.

Q. And, of course, that result would have followed in the case of the St. Francis Basin as in the closure of the other basins?—A. I know of no reason why it should not.

Examined by Mr. BERRY:

Q. You stated a short time ago that you thought the return water from the St. Francis contributed to make the height at Helena?—A. Yes, sir.

Q. Would not that take it out of the general idea which you have—that the closing or leveeing of the river would raise the water?—A. Well, the elevation is under different conditions. In the one case it arises from delayed water in the basin superimposed upon a high stage of water in the main river. In the other case you have a complete confinement from the time the water enters this area, and, under the prolonged stage of this flood of 1897, I should be inclined to think that there would be at least an equal gauge reading at Helena, and probably an excessive one, if the basin had been closed.

Q. If it had been closed, would not the water have passed with more rapidity than with it open?—A. Yes, sir.

Q. Now, you have already answered affirmatively that you thought the return water contributed to the high water at Helena?—A. Yes, sir.

Q. You said that the return water going in above Helena did contribute to make the river higher at Helena than if there had been no return water?—A. Yes, sir.

Q. You still think, however, that that return water, added to the high flood at the mouth of the St. Francis River, would not have made it quite so high as though it had all come down together in the main river. Is that what you mean?—A. The entire water, under the conditions you impose, is confined in the main river, and it has greater difficulty in getting out, then, through the main river, and I do not see why there should not be an increased height of water there; it is confined in the channel and it comes down under the same impulse from above, and I think that experience shows that under like conditions you will have a rise. You find that, in the natural condition of the river, wherever you have a gorge there is an elevation.

Q. And I understand that where it is leveed you think it has a tendency to raise the water in the river?—A. Yes, sir; to increase its flood height.

Q. I am not disputing that at all, but the point I am making is one that was suggested to my mind by Major Harrod, and on which he said he had not made up his mind, and on which Major Handbury said he had not made up his mind—whether or not the fact that the big flood was still on in the Mississippi River when it was joined above Helena by this return water from the St. Francis Basin, if the two combined would not have made as high an elevation as though that water had never gone around into the St. Francis Basin, but had gone on regularly down the main channel?—A. You remember that in the early part of my evidence I stated it was merely a matter of judgment. I feel (in fact, I so stated) that I thought there would be at least an equal elevation of the gauge readings, under the two conditions; and probably a higher elevation in the latter condition; that is to say, because of the confinement by levees, in my judgment, there would be an increased

elevation. It is simply a matter of judgment, and I do not know that it admits of argument. I do not think that anyone can compute it at present, and I should not have answered the question unless it had been persistently demanded.

Q. Well, if I understand you now, taking two engineers of equal ability, one might be justified in taking one view of it and the other the other view?—A. Yes, sir.

Mr. CATCHINGS. You mean, not having been able to test it with the levees all up, nobody can now tell just what it might be?

A. That is my position. I do not believe that the levee construction will cause any diminution of the elevation and it may cause an increased elevation.

Examined by Mr. NELSON:

Q. Well, take the river as a whole, from Vicksburg up to Cairo; the increased heights in the river stages at flood time, within recent years, particularly the flood of 1897, in your opinion is to be ascribed chiefly to the extension of the levee system and the inclosure or fencing out of the basins of the river?—A. That is my position.

Q. And of course that would apply to all reaches of the river; the more levees you build and the more basins you exclude from the river the higher the stage of the water will be in the river, will it not?—A. Yes, sir.

Q. Now, I should be glad to have your views as to the proper method of proceeding with levee construction. In the first place, if you can give it, state the average height of the levees, in the different reaches, above their banks now. I do not expect exact figures, but the average height of the levees in their present condition, and how much they would be required to be strengthened and fortified and raised above their present level to meet such requirements as were suggested by the flood of 1897, and the further requirement of the inclosure of the St. Francis Basin.—A. In general terms, in the basin between Memphis and Vicksburg I think that the average height of the levees is about 13 feet, although there are places where a very much greater height is found, running up to 20 and 30 feet.

Q. But the average is about 13?—A. The average of the greatest number of miles of high levee would be that, yes. An average means nothing if you compare a levee of early construction with one of late construction. Taking a levee that was built fifteen years ago, where the height was 7 feet, and comparing it with the levee built last year, which more nearly approximates to 16 feet. I do not think that the mean between those two would give you a correct idea of the average height.

Q. But the average height up to 1896 was about how much?—A. About 13 feet.

Q. Up to 1896, the year before the great flood?—A. Yes, sir.

Q. And was that considered a sufficient levee at that time in height?—A. Yes; because in many cases the direction that the commission gave in regard to the construction of these levees was that they should be from 1 to 2 feet (of course we are limited by money), but the intention was to get them at least 1 foot or 1½ or 2 feet above the highest known floods.

Q. Preceding that time?—A. Preceding that time.

Q. And on that basis your levees were constructed prior to 1897?—A. Yes, sir.

Q. On the basis of about 2 feet above the call of the prior floods?—A. Yes, sir; 2 feet, you might say.

Q. Now the flood of 1897 necessitated a call for a still higher elevation?—A. Yes, sir.

Q. How much higher on an average?—A. Many of those high levees were overtopped by a foot or more, and I suppose a fair estimate would be from 3½ to 4 feet.

Q. From 3½ to 4 feet higher?—A. Yes, sir.

Q. That would be the requirement suggested by the flood of 1897 and by the entire closure of the St. Francis Basin?—A. That means simply to hold the flood, without a margin of protection.

Q. Then, if you bear in mind that the prior floods of 1882 and 1883 were higher at Cairo than the flood of 1897, and, as I understand it, the volume of water fully as great passing that point as in 1897, it would follow, would it not, that this great increase in levee height that you speak of arose chiefly out of the fact that so much of the river has been leveed and so many basins have been inclosed?—A. I should think so.

Q. And not from any rise in the bed of the river?—A. I do not think you can take the elevation of the bed of the river into consideration at all.

Q. So that the construction of levees that we are progressing with has aggravated or increased the demand for levee height, has it not?—A. Yes, sir.

Q. It has increased it practically, since 1882, to the extent of 6 or 8 feet, has it not?—A. Just about.

Examined by Mr. BERRY:

Q. I will ask you, in addition to the building of these levees, if heavy rainfalls and water coming out of the White River and the Arkansas and the St. Francis, and other sections of the country, would not also have contributed (if they were heavier than they were in 1882) to have made the water higher below than it was in 1882?—A. Yes, sir. In 1897 the Red River was not at its highest stage——

Q. Well, I was speaking of the principal ones, though—the Arkansas, White, and St. Francis.—A. Of course they all have their influence below the point where they are received.

Examined by Mr. NELSON:

Q. You know, of course, of the estimate made in 1896 as to the cost of completing the levee system?—A. It was requested to be made, by myself.

Q. Now that was made at a time and in view and in light of the situation as then known, was it not?—A. Yes; that was one controlling influence. Another was that when I was made a member of the commission I was handicapped for want of information. I never had been on the river as a district officer, and there were many of the physics of the river that I knew nothing about, and one of the first things that I desired to ascertain was the ultimate cost of the execution of the project. In looking up the records I found practically only one estimate, which was, as I remember now, $33,000,000 for bank revetment and water contraction methods and the small estimate of $11,000,000 for levee construction. I could not find anything which made me certain or positive what the estimate in the minds of the commission was as to the ultimate cost. I never had heard any of the deliberations of the commission, and knew nothing as to what the plans under execution at that time were based upon. The commission had made many investigations, which concerned a river of larger magnitude than had ever

been considered for improvement or contraction purposes, and I did not know where the commission stood.

Therefore, as a matter of justice to me and for my own information, I requested facts on various points, and committees were formed to consider, first, the plan and scope of the commission. What are you doing? What do you expect to do? What results do you expect to reach? Second, the character of the contraction works, their extent, and their cost (clearly called for in the organic act of 1879). The third point was the ultimate cost of the work necessary to complete the levee system from the point to which it had then progressed. The estimate that you refer to is the estimate made by the committee on levees, and was based on a grade 2 feet above the highest flood then known to the committee.

Q. Two feet above the grade of the highest flood then known?—A. Yes, sir; assuming that the whole system were completed 2 feet above the estimated level that the waters would then take.

Q. And that standard, in view of the experience of the flood of 1897, would be an insufficient grade, would it not?—A. Yes.

Mr. CATCHINGS. Did I understand you to say, Colonel, a moment ago, that prior to the flood of 1897 the commission regarded the levees already in existence as sufficient to control such a flood as that of 1882? Do I understand you to mean that the levees constructed up to 1896—the recent Government levees—were then deemed sufficient to withstand such a flood as you had had before?

A. Well, do not understand me as meaning that this referred to a completed system at all. Levee construction is progressive. It was not necessary to build in parts the levees to an excessive height. The levees were only built in accordance with the highest level then known, and the engineers would establish a grade, you know, for the level as they knew it. But of course when we came to get the estimate that we called for, we had to assume the whole levee system as completed, and we had to predict a height to which those waters would go, and then assume a height still above that in order to give the full height.

Q. And that was 2 feet, as I understand it?—A. I think the estimate was from 1 to 2 feet; I am not sure about that. There was a prediction in it that was not subject to calculation; that is all. Two feet above the predicted flood height.

Q. Now, to get at this exactly. Prior to that estimate your commission had, as a commission, in cases where you were constructing these levees and had laid out the work, fixed a level grade (if I may use the expression), had you not?—A. A protective grade, considering the highest known water at that time.

Q. Prior to that estimate?—A. Yes.

Q. And the estimate you then made allowed for 2 feet more?—A. In some places it did not allow as much as that.

Q. But not over that?—A. No; not over that. The object of that, Mr. Chairman, was this: We wanted to spread the money as far as we could.

Q. I understand that, but what I am trying to get exact information upon, for the benefit of the committee, is whether the grade that you based your estimate in 1896 upon would be a sufficient grade considering the experience developed by the flood of 1897, with the further fact added of the complete inclosure of the St. Francis and all other basins along the river?—A. Well, I did not attend the meetings of that committee, and all of the reasons for their recommendations were never

given, but I think their estimate is reasonably large. I do not think there will be a very great variation from it.

Q. Do you mean to say that you will not have to build to a higher grade than you contemplated in 1896?—A. Not with the margin given.

Q. And that was 2 feet?—A. That was 2 feet above the predicted height that would be given by the completed system.

Q. Did the commission then predict that there would be an increased height of from 2 to 3 feet?—A. Yes; but their predictions were not nearly reached in some places, and more nearly reached in others.

Q. The flood of 1897, from Vicksburg up to Helena, developed an increased height of from 3½ to 4½ feet to be necessary?—A. Sometimes it went down to 2 feet, as I remember it.

Mr. CATCHINGS. Well, do I understand you, Colonel, that the line which you had in mind in making your estimates and predictions would not have been exceeded by the flood of 1897, except at a few points?

A. It would not have been reached in many cases.

Q. Your predicted line would have been sufficient, except in one or two cases?—A. I say I think that the predictions of the committee were not nearly reached in some cases, and more nearly reached in others. That is the only way I can express it.

Q. What I wanted to know was whether the estimate of 1896 was large enough, in view of the flood of 1897, and in view of the fact that all the basins should be closed up?—A. Unless there has been some serious error in the computation, I do not see why it should not be reasonably near the estimate.

Q. Do you not think it would be better, in view of recent conditions, to have a reestimate made?—A. I do, possibly; but I do not think it would vary much from that determined by the predicted readings of the gauges.

Q. What, in your opinion, is the best mode of proceeding with this levee work, and what would you suggest in reference to it?—A. I think that, Congress having decided that the valley shall be protected, it is the duty of the commission to go on and to construct such levees as will most nearly meet the intent and wishes of Congress in that matter.

Q. Given ample funds to work with, within how long a time could you reasonably perfect the system?—A. The yardage to be built, according to the estimate, is about 120,000,000. The total cost would depend entirely on the cost per yard. If the cost were 15 cents a yard, the total cost would be $18,000,000. It ought to be done, I should think, without taxing too greatly the force in the valley, within five years.

Q. And it is your opinion that it could be completed for how much?—A. That is simply an estimate, Mr. Chairman, assuming the cost at 15 cents per yard. I do not know what influences may tend to either increase or decrease the cost with reference to 15 cents a yard. I understand that the levee work to-day, under the conditions which were imposed by the Secretary of War, costs about 25 per cent over 15 cents. Under certain conditions the price might again be reduced to 15 cents, or even less.

Q. Suppose you had complete authority and ample funds, in what way would you proceed with the work, upstream or downstream, in view of the conditions that exist?—A. I would begin certainly where the largest interests are to be protected. I believe in beginning at the lower end and working upward.

Q. That would be the natural and legitimate and safe way?—A. Yes, sir.

Q. Now, be kind enough to give us your views on the so-called revet-

ystem and the contraction system and their utility and advantages, ıe practicability and necessity for their use and employment.—A. the organic act was passed the commission (as I get from the ls) considered these works in the order of priority given in that The contraction works came first—the bank revetment and con- on works in the channel—the idea being, as I suppose, to bring igh-water channel and the low-water channel into coincidence, ıcting the low-water channel to that width which the natural con- s of the river showed gave the best water, which was about 3,000

de from these contraction works there were other forms of work, esign of which was to diminish the high-water exit—high-water el—it being of prime importance that in case of these channel the banks should be held and the river maintained in a fixed and vable position. That was considered of prime importance. Other- vorks that might be put in to-day for the contraction of the chan- ight be left entirely out of the channel next year by the water. he early considerations of the commission, as I gather from the ls, were given to four reaches of the river. One was the New d reach, where the high ridges are first observed and where there ırtial expansion of the river, after leaving the New Madrid area ss section, and where there have always been, so far as I know, ls of great change. Sometimes the channel depth was favorable vigation, and then again the difficulties were about the same as ve experienced in that same reach the past two years. Then the Plum Point reach, then the Memphis reach, then the Lake lence reach. The commission decided it best to begin on only these reaches first, the Plum Point reach and the Lake Provi- reach. Those reaches were worked on for a series of years, and $8,000,000 was expended, and, when I saw them for the first n 1895 (which was during the low-water season), the channel gave excellent depths as compared with other reaches of the river. you may say that, although the cost was comparatively large thing is large on the river, the river itself is large), the benefits ed were considered advantageous—were about what ought to been expected. If you had gotten greater benefits you would considered yourself probably very fortunate for that expenditure ney.

course, these works suffered from circumstances for which the ission was not responsible. During the progress of this work tion was adverse, and the Lake Providence reach especially was d. I think the cost would have been very much less if the legis- had been different. But, notwithstanding the legislation, it does em to me that the cost was extravagant, and if an engineer, work- ı a river like this, with all of the influences against him, gains ing, I think he ought to congratulate himself. But two or three ago the commission decided to change its policy with regard to ork of improvement by contraction works; that is, suspended finitely, I suppose.

That was not owing, was it, to a feeling of the inutility of the out more on account of the expensiveness of it, was it not?—A. not express an opinion about anyone's action in that matter. All v is their vote on the resolution. It was stated that the cost was reat, $30 a foot, which is at the rate of about $150,000 per mile, at the whole length of the river to be improved extended from to Vicksburg—to be revetted, I mean—and it was estimated that

considering the past history of the river, at least two-thirds of the length of a single bank line would be necessary to be revetted.

This brought the ultimate cost of this construction up to what seemed to us pretty large figures, and the majority of the commission decided it best to suspend that kind of work, limiting the bank revetment, which is one part of the work of improvement, to such localities as it would seem absolutely essential to protect in that way. Judge Taylor, Major Harrod, and others have indicated where those localities were. They were, in fine, the harbors of the river, such as Vicksburg, New Madrid, and other places; the revetment of the banks to prevent cut-offs, also the revetment of banks upon which rested important levees.

Q. To protect the levees?—A. To protect the levees.

Q. Do you think that the revetment system ought to be continued as supplementary to the levee system?—A. If the river is to be the ward of the nation in perpetuity (that involves the idea of permanency) it will in the end be (I do not say for a series of ten, fifteen, or twenty years, but when you get into the fifties) much more economical to build revetment in connection with levees. Of course, you will have to spend in the beginning a very large amount of money and get no return for it for a number of years. But, if you are going to consider the river as the ward of the nation in perpetuity, then in my judgment the best way to take care of it is to begin at the beginning with the idea of permanency before you. In that case, with whatever you put upon the banks of the river, whether it is for the improvement of navigation or whether it is for the protection of the inhabitants, or the interests centering on its banks, you must begin with the idea of permanency, and you can get permanency in no other way than by the present system of bank revetment or some substitute equally good, starting at the upper portion of the river where you first meet your enemy; that is to say, the point of largest delivery at the flood waters.

Q. How do you regard the value of the contraction system?—A. I think I have expressed myself on that point, that the contraction works, constructed by the commission, were successful. Certainly Plum Point reach is in very much better condition than it was in the beginning, and I can say the same thing of the Lake Providence reach.

Q. As I understand you, you believe that the contraction system and the revetment system should be adhered to, if we are going to consider the navigation of the river?—A. In my own mind (I criticise nobody, I speak for myself as a member of the commission), if I had the power to do with an unlimited amount of money just as I chose, I never should dredge a particle except for temporary relief. Dredging has been substituted by the majority of the commission for these contraction works. Of course, it is very apparent that it was done with a view to hastening the facilities that were originally designed by the organic act to be given to navigation. It was supposed by some members of the commission (at least the records seem to so show) that these contraction works would be assisted by the levees in deepening the channel at low stages. I myself have never found anything to create in my mind a conviction that the levees would ever have any beneficial effect upon low-water navigation. I do not see how it is possible to give a more uniform bed to the river and to give a better low-water navigation by the construction of levees than you would have in unleveed conditions.

Q. You can only do that by the scouring system?—A. Scouring has a tendency to lower the bed, but it does not necessarily tend to make it more uniform.

Mr. CATCHINGS. Some engineers, as I understand, while agreeing

ith your statement that the construction of levees does not deepen ıe low-water channel, yet have the opinion that the maintenance of vees tends to diminish the deterioration of the river by diminishing .e formation and rapid movement of the bars. What would you say ›out that?

A. I have nothing to justify an expression of opinion on that subject. ndoubtedly, Mr. Chairman, dredging is a very excellent thing. It ves you a very rapid means of crossing these bars, at a period when mmerce absolutely demands an increase of water in order to accomodate the vessels as we now find them navigating the Mississippi ıver and carrying produce; but we are confronted with this problem, at if you suspend your dredging any one year you must go back to :actly the same condition that the river was in twenty-five or thirty :ars ago. It has not a particle of permanency. The river is subject › oscillations not only from year to year, but even during the navigable seasons; the moment you have a rise of the river which gives you ny accumulation of material, that material will deposit on the first ar it reaches, and therefore you may find it necessary to attack a bar vith your dredge two or three times in the working season. So it ertainly contains nothing of the idea of permanency.

Q. It merely gives temporary relief?—A. Yes, sir.

Mr. CATCHINGS. Colonel, assuming that the appropriations of Congress for channel work such as you describe (the revetment and contraction works) would be no greater in the future than they have been in the past, would you maintain the dredge boats that we now use in aid of commerce, or would you use such small amounts of money as would be at your command (under my assumption), for building revetment works and contraction works, and let commerce in the meantime suffer?

The WITNESS. I think that question has been answered, General Catchings. For the first period of revetment work there would be, probably, a period of ten years when you would not see any beneficial result at all. Now, during that period, or even a longer period, it would be absolutely essential to continue dredging, but I do not believe that we could tell to-day, or five years from now, the number of dredges :hat we would need. It may be that the number we have provided for vill be ample. On the other hand, it may be that double the number vill not give adequate relief, depending on the conditions that we find onfronting us in any one season. Now, there are in the neighborhood f forty bars, say, on the river. We can not tell how many bars a single dredge can take care of in one season. If we could, the problem ould be easy of solution. If it is found that the oscillations are very reat for a series of years, it might be that we would need one dredge orking constantly for every two bars, or to have dredges stationed at oints where they could be easily accessible. They would not be necesary for continuous work, but should be so situated that they could be alled upon and utilized, without delay to commerce, at any obstructıg point where we find very shoal water. And we must always have eserve dredges in case of breakdowns. Dredges break down like teamboats or any other articles.

Q. Colonel, there is more or less constant scouring and filling of the ed of the stream going on all the time in all stages of water, is there ot?—A. Yes.

Q. At what stage of the river is there the most scouring—at the igher stages, flood stages, medium stages, or low stages?—A. The couring takes place in the higher stages of water.

Q. In the bed of the stream, I mean.—A. Not necessarily the bed; wherever the material is found to be the most subject to attack. It depends entirely upon the composition of the banks and the nature of the bed. If the bed is more erosive than the banks, the bed will go. At the same time if the banks are weak they will go; or the bed and the banks may go coincidently.

Mr. CATCHINGS. Colonel, is it your idea that even if you should assume that the confinement of floods by levees would lower the bed of the river, that still, when it came to low-water navigation, the same difficulties would exist? In other words, merely lowering the bed does not improve the low-water channel?

A. My opinion is that the difficulties of crossing between the pools would be the same, unless the scouring process is found to equalize this material more than I believe would be done.

Q. So that lowering the bed would relieve as to overflow, but not at all as to navigation?—A. Yes, sir.

Q. Is there any immediate or direct preventive that can be utilized to prevent the formation of bars and pools in the bed of the river?—A. I do not know of any.

Q. That purpose can be accomplished only by dredging?—A. After they have been formed dredging may remove them.

Q. But aside from that there is no way of relief?—A. None that I know of.

Q. The building of levees, then, will not help that matter?—A. I think not.

Q. The building of the levees alone will not afford any material help toward improving directly the navigation of the channel at low water?—A. I do not see how it can. Other devices besides dredging have been suggested to accomplish that result. Numerous devices have been presented to the commission, all of which have been studied. One is the portable dike system. Major Handbury and his predecessor have tried it. Colonel Stickney has made several propositions; but the only device which has had an extended and rapid practical application that we know of for removing these bars with facility is dredging.

Mr. CATCHINGS. Some engineers have an idea, have they not, that the bars subserve a very useful purpose in the economy of the river?

The WITNESS. Yes, sir.

Mr. CATCHINGS. And that any system of improvement ought not to look to the entire removal of the bars but only to the making of a navigable channel across them, and never to remove the bar below a level which is adequate to your purposes?

A. I have known rivers that have been wholly exhausted by defective engineering.

Examined by Mr. VEST:

Q. I understand you now to state, Colonel, that the building of levees on the two sides of the river and the confining of the water inside of them has no effect upon the channel for navigation?—A. No beneficial effect that I can conceive of. You mean at low water, do you not?

Q. I mean at any stage of the water. If you can confine the volume of water to the channel, would not that increase the scouring capacity?—A. Yes, sir.

Q. Would not that improve the channel?—A. Not necessarily. You might dig it into holes and rearrange the material, but——

Q. That might be, but what is the general effect; what is the purpose of confining the water unless it is to scour the channel?—A. It is to

ake a uniform breadth of conveniently navigable depth throughout e channel that is so improved. We are speaking now wholly of low-ıter stages, as I understand it. If you confine your water at low stage the channel, you increase your depth, but your high-water scouring ll not do it alone.

Mr. BERRY. Did not the jetties have the effect of making a deeper annel by scouring?

The WITNESS. Yes, sir.

Mr. BERRY. And better navigation?

The WITNESS. Yes, sir; right at the mouth of the river. But we e speaking now of the trunk of the river, which is an entirely dis-milar case.

Mr. CATCHINGS. Your idea (to use an illustration) is that even if the fect of the levees should be to lower the bed as much as 10 feet, that ill, when that bed is lowered, it would probably be as sinuous and ırtuous and difficult to navigate as it is now?

The WITNESS. Yes, sir.

Mr. VEST. It would not do any good, then, to build the levees, as far ; navigation is concerned?

The WITNESS. Not that I can see, sir, not a particle.

Mr. CATCHINGS. Speaking of low-water navigation?

The WITNESS. Yes, sir. Of course, we do not now consider the high ages. The mere fact of the water being high makes the stream navi-ıble. The time of trouble is during the low stages of water.

Examined by Mr. VEST:

Q. Now, suppose you had $20,000,000 to apply to the improvement the river. What would you advise the committee to do with it?—. If I had it to apply in any way that the commission desired?

Q. Yes.—A. That is a matter on which the most conservative minds ight differ. Having observed the benefits arising from Plum Point ıd Lake Providence reaches, I should take two other reaches and ıdeavor to still further improve the low-water navigation, which in ose reaches has been benefited by improvement of that kind. I ould endeavor to protect as much of the valley by the levees as I uld. The amount that I would apply in that way would depend upon e degree of profection which the levee system had reached at that ne. I take it for granted, when you ask me that question and give e $20,000,000, that you mean to consider the river as we find it day?

Q. Yes.—A. With the levee system as nearly completed as it is?

Q. Yes.—A. Well, then, in that case I should continue the levee stem proposed by the commission, and then, without making an off-ınd division right here—it would be more than unjust to yourself in king the question to attempt to do it—I should endeavor to apply the sidue in the way which would best preserve and extend the works r river navigation as we have planned them heretofore.

Wherever there is a tendency to cut-offs the bends ought to be vetted, and I think those parts of the river which furnish the worst ıvigation should be treated in exactly the same way that the com-ission treated Plum Point and Lake Providence reaches. I know at course is open to criticism. I suppose a great many persons would y that we were doing wrong. But if we have not the power of elec-ɔn to take the river and treat it as we desire to treat it (with the full nount of the estimate for complete protection not wholly in our hands),

then I would say do the best we can and let the future take care of itself.

Q. As I understand, you would apply it first to the perfection of the levee system?—A. Yes, sir; of course reserving a certain amount of money for immediate purposes to relieve navigation. Those two considerations I think were the foremost considerations in the minds of Congress when they passed the organic act—to improve navigation and to protect the abutting owners.

Mr. GALLINGER. I think Senator Vest assumed that you had $20,000,000. If you completed your system with that you would not have anything left for any other purpose, would you?

The WITNESS. Of course the $20,000,000 would not complete the levee system, and I would not put the whole of it into levees.

Mr. NELSON. From your remark I gather that you think it would take more than $20,000,000 to perfect the levee system.

The WITNESS. I can not give an exact answer to that.

Mr. NELSON. It would take at least that?

The WITNESS. It would take at least twenty millions.

Mr. VEST. I could not hear you.

The WITNESS. It would take about twenty millions, I think.

Mr. NELSON. It would not be less than that?

The WITNESS. I think not.

Mr. NELSON. It might be more?

The WITNESS. It might be more.

Q. I understood Major Harrod to say that it would take about $20,000,000, or possibly a little more, to complete the building of the levees properly from Cairo to the mouth of the Red River. The estimate we had already had was $18,000,000, but he said that, on account of the experience of the last flood, it might require $2,000,000, or a little over $2,000,000, more. That is the reason I stated that amount of $20,000,000 in my question. What I want to get at, Colonel Gillespie, is what you think would be the most important thing to do for the river if you had just $20,000,000, or about that sum. You have already stated what you would do with an unlimited amount, but assuming that you can not get an unlimited amount and that you had $20,000,000, then what would you consider the most important thing to be done with that amount of money?—A. That is a very difficult question. If I were to determine the matter, I think my decision would be controlled entirely by personal considerations. I should not, on the whole, come to think of it, devote more than $10,000,000 to levees. I would make it half and half—half for the improvement of navigation and half for levees.

Examined by Mr. BERRY:

Q. Then if I understand you, Colonel, you say that you think it would not be practicable to apply this scouring process so as to make it the best means of improving navigation all along the river, as it is applied at the jetties, but the revetment system, such as the work at Plum Point and Lake Providence, is done with the idea of making a uniform channel in the river and thereby eventually improving the navigation?—A. Yes, sir; at low stage.

Q. Confining it to the same channel and preventing the caving, etc.?—A. In many places the channel width is 4,000, 4,500, or 5,000 feet, and one of the first things that engaged the attention of the commission was to closely search this river from beginning to end to find out where the best water was to be found and to study that water with

lation to the channel width, and the commission very early arrived the conclusion that it was not advisable to make that channel width 000 feet, or between 3,000 and 3,500 feet.

Q. That character of work would only be required from Cairo to icksburg?—A. From Cairo to Vicksburg. Below Vicksburg they d 10 feet of water, and the commission made no provision for any provement below that.

Examined by Mr. VEST:

Q. Colonel, you have seven members of the commission?—A. Yes, r.

Q. Where do they reside?—A. There is no requirement in that gard.

Q. I know; but where do they actually reside—the present mem- ers?—A. The commission is composed of, first, the president of the ommission, located in New York City; then Major Harrod, who resides New Orleans; the next civil member is Judge Taylor, who resides in ort Wayne, Ind.; the Coast Survey member resides in Washington; olonel Stickney resides in St. Louis; Major Handbury resides in St. ouis; Colonel Flad resides in St. Louis.

Q. So there are three members who reside in St. Louis?—A. There e three members residing in St. Louis; yes, sir.

Q. Who fixes the place and time for the meeting of the commission?— . The president of the commission. And that is determined by the tes of the passage of the appropriation bills.

Q. Well, the place at which the commission meets is fixed by the esident?—A. Is fixed by the president, and is usually in the office of e president.

Q. Where is the secretary's office?—A. In St. Louis.

Q. And all the papers of the commission are kept there?—A. The pers of the commission, so far as relates to the general surveys of e commission and the duties particularly confided to the secretary. nder the commission there are (these) three constructing officers of e Corps of Engineers, with whom the secretary has no relation what- er except a general one. They are under the immediate orders of e president of the commission, and through the president all their ficial papers, projects, and so on go before final action is taken by the ar Department. They are practically two distinct offices—that of e president and that of the secretary.

Q. The office of the president being in New York and the office of the cretary being in St. Louis?—A. Yes. The secretary has charge of e various gauges, and also of the dredging operations. No dredging eration is conducted by any district officer except the fourth district ficer, Captain Derby, who has a single dredge under his control, and ith that dredge he has been accustomed to open the mouth of the Red iver and remove the bars between Red River and Natchez, and for a nited period he has attended to, and rather successfully, the making levees by the deposit of dredged material on the land.

Q. What is the compensation of the members of the commission?— . The compensation of the civil members is $3,000 a year and actual xpenses. The officers of the Corps of Engineers receive no increased ay.

Q. But are paid their expenses?—A. They are paid their expenses, as ny other officers in the service.

Q. Does that include mileage?—A. Yes, sir.

Q. What is the mileage?—A. Four cents a mile.

Q. Each way or both ways?—A. Four cents a mile for every mile that is traveled.

Q. Going and coming?—A. If we travel on a Government boat like this we do not get any mileage.

Q. But suppose Colonel Stickney goes from St. Louis to New York to attend a meeting. Does he get mileage going to New York, or going to New York and coming back, too?—A. He gets 4 cents for every mile he travels.

Q. Why are these meetings held in New York, instead of being held in the vicinity of the river and the people who are immediately interested in the river?—A. Well, the law directs that the senior officer of Engineers shall be the president of the board, and he has usually heretofore been selected with the rank of colonel, and it would seem that the services of an officer of that rank ought not to be reserved wholly for the use of the commission. There is one lieutenant-colonel at St. Louis, Colonel Stickney. Major Handbury is stationed there also, so it takes three members of our Corps, of high rank already, for this work.

And so, while this work is considered very important, the War Department has never been able to find a sufficient number of officers to detach one officer of high rank for sole duty with this commission. As president of the commission, I have many other things to attend to. I am a member of the Board of Engineers for New York. I am the division engineer of the northeast with supervisory authority over the Atlantic coast from Barnegat to the boundary line of Canada, and Lakes Erie, Ontario, and Champlain. I am also an associate member of the Harbor Line Board of New York, and many other small boards. And it is more convenient for me, as the presiding officer of the Mississippi River Commission, to have the meetings held in New York City, because I have no increased force for that work. With the force I have in New York City, consisting of only two men, I perform all this work myself.

Examined by Mr. NELSON:

Q. What would you think of the propriety and advantages or disadvantages of placing the entire levee system under the jurisdiction of the Federal Government, under proper conditions and restrictions? Would you think that would be preferable to the present system?—A. Are you considering now simply the levee system or all the work on the river?

Q. The levee system of the whole river.—A. Certainly, that has advantages, because it insures uniform treatment of the alluvial basin from the Passes to Cairo under a single or centralized power, giving lines of levee selected by the highest expert authority that can be gotten, and the work could be continued in a way to insure the best results for the expenditure of the money. That is one view of it. Another thing is the confidence that this continuous construction would give to persons not only living in the communities along the river to-day, but those who might be attracted there by the protection that would be given to these valuable lands. The confidence I speak of would rest mainly upon the almost promised assurance that the money would be forthcoming annually in proportion to the needs of this part of the country. It would be considered somewhat more reliable, I fancy, than if the appropriations were left to the States. I think that in any such proposed arrangement the interests of the General Government should be very carefully guarded by appropriate legislation. I am not able to say what that legislation should be, but I think that the obligations of the United States should be clearly defined and ample protection be given to the Government against all classes of claims for damages arising from the building of levees or their destruction during freshets.

Q. Would you not to a certain extent, if the Federal Government ›ok charge of the work, be relieved of the embarrassment growing ıt of the present system of allotting certain lump sums for certain ›aches of the river?—A. Am I to answer that question in connection ith the absolute control of the system by the Government without any int action on the part of the States?

Q. Yes, sir.—A. The Government of the United States taking it in ınd, and making all the preparations, and doing all the work?

Q. Not appropriating all the money, necessarily, but having complete ›ntrol over it. Assuming that the Federal Government appropriates ıe-half and the State or local authorities the other half.—A. Well, that ıatter has been considered only since it was first presented to my mind y the questions of the committee, and I am not thoroughly satisfied et how an adjustment of the appropriations of the United States and he States can be made. I do not believe that any officer of the Gov- rnment can assume the expenditure of State money without subjecting ıimself to the same kind of influence to which the State officers are ıubject.

Q. Supposing the local or State money were not payable directly to ıim, but payable into the Treasury of the United States, and made ıvailable, like the direct appropriations of Congress—put into one lump um. Suppose it was in your hands, so that the commission had noth- ıg to do with the State officials in regard to the securing such funds 'om them?—A. I see no reason, then, why State money should not be ›pended with the same facility as United States money.

Q. Is it not a fact that the commission has sometimes been embar- ıssed in your present system of work by local pressure for work here ıd there at different points in preference to other points?—A. I have ›t been on the commission long enough to know anything about that. ell, yes; some little pressure has been brought to bear, but there has een nothing that the commission has not acted upon irrespective of ıat pressure. I can conceive that, when the work was first initiated nd larger appropriations were gotten, such pressure may have been ery strong against the commission. I do not know that they have ielded to it.

Q. But pressure was brought to bear to give some localities a priority ver other localities, was there not? I do not mean to imply that the ›mmission has failed in its duty, but I mean has it not been a source some little embarrassment to the commission?—A. I have no doubt ıat it has been, but I do not know of my own knowledge——

Q. I mean, whether it has not been one of the difficulties that they ıve had to contend with occasionally?—A. I can conceive that it may ıve been, Mr. Chairman.

Mr. CATCHINGS. And yet, Colonel, has not the only pressure come the form of appeals by delegations before the commission in open eeting? Has there been a pulling and hauling of the members indi- dually and personal appeals and pleadings?

The WITNESS. None that I have heard of. All the pressure that I ıve known of has come through letters submitted to the president ıd speeches and appeals which have been made to the commission in ›en meeting.

Mr. BERRY. The statements at the open meetings were always made ıder an understanding that the commission was willing to hear repre- ıntatives from the different reaches of the river, were they not, Colonel?

The WITNESS. Not only willing, but, so far as my intercourse with ıe commission has shown, very anxious to hear them.

Mr. BERRY. And whatever was said was said openly and publicly?

The WITNESS. Undoubtedly. I understood your (the chairman's) question to mean that possibly the commission, under certain circumstances, had made an application of money which their own good judgment would not have dictated. I know of no such case.

Mr. NELSON. That is what I meant—whether you had not sometimes, under pressure, been compelled to yield your best judgment to comply with local requirements.

The WITNESS. I know of no such application of money.

Mr. GALLINGER. Colonel, in view of your testimony that the levee system does not improve the navigability of the river, but simply protects private property from injury, does it not follow that appropriations made by Congress for that purpose are in the nature of donations to the communities where the money is expended?

The WITNESS. Well, I do not know that I have the power to judge what a donation is. The organic act specifies work for the improvement and increase of the then existing navigable facilities, and then it goes on and speaks of protection against floods. Now I have always said, since I have given any considerate study to this question (and I have done the best I could with the limited opportunity I have had to study the question), that, so far as I know and so far as I can observe from the results of the commission's observations, the construction of levees has had no beneficial effect upon low-water navigation. Now, if money is appropriated for the construction of levees, it is appropriated in accordance with that expressed provision of the organic act.

Examined by Mr. CATCHINGS:

Q. The commission is charged, under the later language of the law, with the improvement not only of the low-water navigation (which is all you have testified about), but also the navigation of the river at all stages, which would include flood stages.—A. That is the provision contained in the act of 1896.

Q. And also in the act of 1892.—A. Perhaps so.

Q. Now, I would like to ask if commercial and navigation interests on the river are not greatly benefited by the prevention of these floods. Can not boats navigate with much more safety when the water is confined, and also have landing places, which they would not have if the country was inundated?—A. Yes; they have landing places, and it gives navigation a more sure intercommunication——

Q. Between the States?—A. With the land. It probably protects to a degree the business of the railroads.

Q. Does it not enable commerce to be carried on, for instance, between the city of St. Louis, we will say, and all the cities lying along this river, which might not be carried on at all if the whole country was under water, and so is not interstate commerce greatly benefited by the construction of these levees?—A. Undoubtedly commerce is protected, but I do not know that I am able to put myself on record as to the degree in which it is protected.

Q. I am not speaking so much of the ability of a boat to travel along; of course it can do that when the water is high. But if this whole country were overflowed for two or three months would it not greatly interrupt the relations existing between the States of the Union, and especially those States that do business in this valley?—A. Yes, sir. The mere fact of submergence is an indication that that relation has been disturbed.

Q. And a great injury to the business of the States?—A. It depends irely upon its quantity.

Q. So that levees perform a function in addition to that of merely venting overflows?—A. Yes.

Examined by Mr. BERRY:

Does not the law specify trade, commerce, and the postal service as tters to be protected or subserved by reason of the improvement of river?—A. Yes, sir.

Q. Now, I will ask you if these levees do not protect the railroad beds many cases throughout the valley, and also, if there was a general erflow of this river, if it would not materially interfere with the comrce between the various States that do business through the valley?—I think so. When the railroads were originally built, as I underand, they were given a height of embankment to secure them against ordinary floods. But if the levees are raised higher, being nearer bank than the railroad embankment, if they are raised high enough cover those railroad embankments, of course they do protect the ilroads.

Q. And a general overflow would materially interfere with a large ount of commerce, would it not?—A. It undoubtedly would.

Q. And an immense amount of cotton that is now raised and the bject of commerce would not be raised if the land was overflowed. general overflow would destroy an immense amount of cotton lands d cotton which is now raised throughout the valley, would it not?—That is true without doubt.

Mr. GALLINGER. Is it not a fact that notwithstanding the great erflow of 1897 the largest cotton crop ever known was raised during at year?

Mr. CATCHINGS. That is a fact, Senator, but it was owing, as all the inters agree, to a very exceptional season for a late crop, followed an unusually late frost. I heard old Mr. Dunkins say this last fall ho is a large planter and a very intelligent man, and who has lived Washington County for fifty years) that this is the first time in all his perience that he has known a general good crop to follow after an erflow. He said there were individual plantations which had raised od crops, but usually half a crop was more than they had a right to pect.

Mr. BERRY. I can add to that, if there had been no levees, this cotton p would have been materially reduced.

Mr. GALLINGER. I would like to know whether any data can be ained showing the extent to which railroad travel was interrupted the recent flood or by any preceding flood.

Mr. CATCHINGS. Some gentlemen who are interested in this general estion have been engaged for several months in gathering informan cognate to that, and it is their purpose, before this committee kes its report, to lay it before you in Washington. I think you will ve all that laid before you before your report is closed.

The WITNESS. I would like to submit this paper, which is in regard the yardage of levees built by the United States and others and the t, for the use of the committee, until the paper which was asked for prepared according to your specific directions.

I would also like to submit another paper for the consideration of the nmittee.

The papers were marked "Exhibits AA and BB," respectively, and follow here:

EXHIBIT AA.

Districts.	River length to be protected.	Yardage, June 30, 1895. Built by United States.	Built by others.	Total existing levees.
	Miles.	*Cubic yards.*	*Cubic yards.*	*Cubic yards.*
Lower St. Francis	218	1,689,000	2,682,000	4,371,000
Upper Yazoo	121	3,688,000	6,746,000	10,434,000
White River	80	2,971,000	1,395,000	4,366,000
First and Second districts	419	8,348,000	10,823,000	19,171,000
Lower Yazoo	230	4,918,000	14,665,000	19,583,000
Upper Tensas	120	7,910,000	1,340,000	9,250,000
Middle Tensas	85	3,854,000	5,401,000	9,255,000
Third district	435	16,682,000	21,406,000	38,088,000
Lower Tensas	160	5,672,000	5,235,000	10,907,000
Atchafalaya	122	5,287,000	7,009,000	12,296,000
Lafourche	71	1,500,000	4,093,000	5,593,000
Barataria	92	337,000	1,400,000	1,737,000
Homochitto	238	.....	(1)	.....
Pontchartrain	116	4,173,000	5,464,000	9,637,000
Lake Borgne	82	377,000	1,720,000	2,097,000
Fourth district	881	17,346,000	24,921,000	42,267,000
Grand total	1,735	42,376,000	57,150,000	99,526,000

District.	Expended by United States. Total expenditures.	Per cubic yard.	Total allotments.	Available for expenditure from June 30, 1895, to June 30, 1896.	Present average price per cubic yard.	Yardage that may be built with available balance.
		Cents.			*Cents.*	*Cub. yards.*
Lower St. Francis	$329,669.29	22	$420,164.03	$90,494.74	12	750,000
Upper Yazoo	714,095.41	19	800,304.00	86,208.59	12	750,000
White River	659,739.81	22	793,387.38	133,647.57	13	1,000,000
First and second districts	1,703,504.51	21	2,013,855.41	310,350.90	.....	2,500,000
Lower Yazoo	1,291,974.55	26	1,435,285.24	143,310.69	10	1,040,000
Upper Tensas	1,777,661.23	22	2,069,675.23	292,014.00	11	2,600,000
Middle Tensas	801,851.77	21	1,003,150.96	201,299.19	10	2,000,000
Third district	3,871,447.55	23	4,508,111.43	636,623.88	.....	6,000,000
Lower Tensas	1,552,547.16	27	1,654,837.20	102,290.04	10	1,000,000
Atchafalaya	758,583.44	14	933,018.96	174,435.52	10	1,700,000
Lafourche	318,486.93	21	447,200.00	128,713.07	10	1,300,000
Barataria	156,475.72	47	238,800.00	82,324.28	10	800,000
Homochitto	.....	.....	30,000.00	30,000.00	10	300,000
Pontchartrain	605,707.36	14	759,749.04	154,041.68	10	1,500,000
Lake Borgne	138,100.13	37	199,001.50	60,901.37	10	600,000
Fourth district	3,529,900.74	20	4,262,606.70	732,705.96	.....	7,200,000
Grand total	9,104,892.80	21	10,784,573.54	1,679,680.74	.....	15,700,000

(1) Allotments and expenditures for "protection of levees" and for "Tensas front," are distributed approximately in proportion to mileage.

Cost of levee construction (Harrod) $156 \times h^2$ = cost in dollars per mile at the rate of 20 cents per cubic yard.

Levees.—Mean contract cost for 1890–1892, inclusive, 20 cents per cubic yard; mean contract cost for 1893–1895, inclusive, 16 cents per cubic yard; cubic yards built for 1893–1895, 23,282,000; total contract cost, $3,706,000; saving, 20 per cent, $950,000.

Auth. 3d Dist., A. R. 1895, 3,628; 4th Dist., A. R. 1895, 3,877; 1st and 2d Dists., A. R. 1892–95, comparing levee statements of those districts.

EXHIBIT BB.

LEVEES.

'eet of levees on bed of Mississippi River, with data of the Po, Rhine, and Yellow rivers, by C. B. Comstock.
Report of Chief of Engineers, U. S. A., 1890, p. 3093.
sessed value of property protected by levees in Pontchartrain district.
Report of Chief of Engineers, U. S. A., 1892, p. 3235.
'port of engineers to levee convention.
Report of Chief of Engineers, U. S. A., 1890, p. 3270.
'ngth and distribution of levees.
Report of Chief of Engineers, U. S. A., 1890, p. 3111.
'vees between Cairo and the Gulf before and after the war.
Report of Chief of Engineers, U. S. A., 1893, p. 3762.
'obable average height of levees in 1881 was eight feet.
See Report Mississippi River Commission 1881, p. 125.
andard height of levees fixed at three feet above highest flood.
Report of Chief of Engineers, U. S. A., 1895, p. 3626.
stimated cost of repairing breaks in 1881.
Report of Chief of Engineers, 1881, p. 2733.
eport of committee on levees (B. M. Harrod and Amos Stickney) on amount and cost of levees needed to protect against probable future floods.
Report of Chief of Engineers, U. S. A., 1896, p. 3460.
revasses during flood of 1897, areas flooded and areas protected.
Report of Chief of Engineers, U. S. A., 1897, pp. 3524–3525.
iews as to efficiency of levees during flood of 1897, by the following levee engineers: H. N. Pharr, T. G. Dabney, William Starling, and H. B. Richardson.
Report of Chief of Engineers, U. S. A., 1897, pp. 3543–3561.
ighest recorded stages of the Mississippi River below Cairo, 1872 to 1897.
Report of Chief of Engineers, U. S. A., 1897, p. 3670, also p. 3523.
ie general condition of levees just prior to the flood of 1897.
Report of Chief of Engineers, U. S. A., 1897, pp. 3518–3523.
scussion of results of surveys made for the purpose of determining changes in the bed of the river due to levees or other causes, by J. A. Ockerson.
Report of Chief of Engineers, U. S. A., 1896, pp. 3577–3592, and 1897, pp. 3672–3686.
'surveys showing changes in bed of river due to crevasses in levees.
Report of Chief of Engineers, 1884, p. 2577.
'mages to citizens by reason of floods alleged to be due to levee construction.
Chief of Engineers' Reports for 1894–95.

RESERVOIRS.

'servoirs as a means of improvement discussed by the commission.
Report of Chief of Engineers, U. S. A., 1881, pp. 2747–2753, and report of Mississippi River Commission, 1881, p. 242.
'servoir effect of basins of the river, by Capt. C. McD. Townsend.
Report of Chief of Engineers, U. S. A., 1895, p. 3661.

OUTLETS.

'scussion of outlet system, by Mississippi River Commission.
Report of Chief of Engineers, U. S. A., 1881, pp. 2725–2731.
'ke Borgne outlet discussed.
Report of Chief of Engineers, 1881, p. 2728.
'ports of committee on levees and outlets, by C. R. Suter and B. M. Harrod.
Report Mississippi River Commission, 1881, pp. 122, 135.
Report of Chief of Engineers, U. S. A., 1881, p. 2768.
'scussion of closure of outlets, by James B. Eads.
Report of Chief of Engineers, U. S. A., 1882, p. 2726.
'fect of outlets as shown by cubits and other crevasses.
Report of Chief of Engineers, U. S. A., 1884, p. 2422; 1885, p. 2540.
emorandum on outlets, with special reference to Lake Borgne outlet, by General Comstock.
Report of Chief of Engineers, U. S. A., 1890, p. 3105.
'tlets condemned by engineers in report of levee convention
Report of Chief of Engineers, U. S. A., 1890, p. 3271.
'fects of outlets on the bed of the river below them.
Report of Chief of Engineers, U. S. A., 1891, p. 3465.
'tlets discussed and condemned.
Report of Chief of Engineers, U. S. A., 1893, p. 3560.

MISCELLANEOUS.

Report of Board of Engineers appointed to investigate and report a permanent plan for the reclamation from overflow of the alluvial basin of the Mississippi River.
Consider cut-offs dangerous and useless, diversion of tributaries impracticable.
Reservoirs for holding back floods also considered, impracticable from lack of proper size.
Artificial outlets pronounced dangerous and impracticable.
Levees suggested as the only practicable plan. Condition of levees in 1875. Members of board: Majors Warren and Abbot, Captain Benyaurd, and Messrs. J. E. Sickles and P. O. Hebert.
Report of Chief of Engineers, U. S. A., 1875, pp. 539-628.
Report of Board of Engineers to report plan for low-water improvement of Mississippi River and effect of permanent levee system. Members of board: Colonels Barnard and Tower, Lieutenant-Colonel Wright, and Majors Comstock and Suter.
Report of Chief of Engineers, U. S. A., 1879, p. 1017.
For a full discussion of all phases of the subject of improving the Mississippi River below Cairo, see report of Humphrey and Abbot on the hydraulics of the Mississippi River, Professsional Papers, Corps of Engineers, U. S. A.
Plan of Gen. B. I. Roberts for reclaiming overflowed lands of the Mississippi River by silting up through waste weirs draining into settling basins built up by means of cross levees, also plans for reservoirs and outlets. Reported impracticable by Board of Engineers.
See Report of Chief of Engineers, 1869, p. 312 and 1875, p. 540, 564, and 670.

U. S. S. MISSISSIPPI, *February 7, 1898.*

AMOS B. STICKNEY, recalled, testified as follows:

Examined by Mr. NELSON:

Q. Colonel Stickney, you are a member of the Mississippi River Commission?—A. I am.

Q. How long have you been a member of that commission?—A. About four years.

Q. You are also president of the Missouri River Commission?—A. Yes, sir.

Q. You were examined by the committee at St. Louis last fall, and I have no desire to go into the subjects then covered. As I understand it, you and Major Harrod were a committee appointed by the commission to prepare these estimates in 1896 for the complete improvement of the levee system of the river, were you not?—A. Yes, sir.

Q. And considered it?—A. Yes, sir.

Q. And it is substantially your estimate that is known as the commission estimate?—A. Yes, sir.

Q. I would be glad to know the facts upon which that estimate was based. In the first place, please state upon what condition or status of the levee you based the estimate. In other words, what was the status and condition of the levees as they existed at the time of your estimate, their average height, etc., as near as you can tell, by sections or reaches of the river?—A. Mr. Chairman, before beginning on that subject, I would like to say that I did not expect to be called again before the committee, having given my testimony in St. Louis. But when I came to revise the testimony that I gave I found that it was very fragmentary; that there were a great many things I would have liked to have said that I did not say, and some things that I did say I found were not pertinent to the questions, and, in revising my testimony, I had to make quite a number of changes in order to make my answers complete to the questions that were asked me. The examination was carried on in a conversational manner and with a great many interruptions. I would be very glad if you would give me an opportunity now to make a more connected statement.

Mr. NELSON. I should be very glad indeed to have you make such a statement as you wish before we go into the question of estimate that :eferred to.

The WITNESS. That I will take up in the course of what I have to say. As I understand, this committee, among other things, is to look into e question of flood protection and the work of the improvement of the ississippi River that has been intrusted to the Mississippi River Comssion. I have been a member of the commission for four years. 'evious to that time I had been serving under the commission as a strict officer in New Orleans, having charge of the lower district of e river. Previous to that time I had been on the river for a great any years. My work on the Mississippi River commenced in 1868, ıd, with the exception of a few years on the Ohio and lake region, I ıve been constantly connected with the Mississippi River improveents, from the upper end to the lower end, and I have some pretty ell defined views of what I think is essential in the matter of the nprovement of the Mississippi River. I have jotted down a few things, nd I would like to begin with the matter of levee building. I gave ɔu my testimony pretty fully with regard to what I consider would be ıe effect of reservoirs and outlets, and it will hardly be necessary for e to go over that ground again.

It seems to me that the committee must by this time, in view of the ass of testimony they have heard, be impressed with the concurrence opinion of those who have been in close contact with the subject of ·od protection of the Lower Mississippi Valley that the only practical d complete solution of the problem contemplates the construction and aintenance of a system of levees from the mouth of the Ohio River the Gulf, and that there are many very serious questions arising in nnection with the construction and maintenance of such a system.

First. The effect of the levees.

Second. The cost of construction and maintenance.

Third. The source from which the necessary money is to be obtained, d the advisability of levee building.

Fourth. The question of ownership and control.

Fifth. The question of damages caused by the levees.

There are other questions that will present themselves, but the above, ɔelieve, are the main ones.

First, with regard to the effect of levees. It is believed by those ıo have been connected with this subject of levee building that lines levees can be built that will absolutely and completely protect the ver valley of the Mississippi from any flood that may come into e river, and give to the present and future inhabitants such conence in their protection that they may proceed to the full developent of the resources of the whole area lying within the limits of evious overflows.

That gives you, in very brief terms, what I believe comprehends the ıole subject of the levee protection that is desired by the people of e Lower Mississippi Valley, and it comprises all I have to say on the bject of flood protection.

There is another effect of levees to be considered, and that is the 'ect of the levees upon the bed of the usual waterway of the Misıippi. I believe it to be that which always follows the increasing of lume and velocity of the flow of water in a channel composed of mateıl that can be moved by the water, that is, scour—producing enlargeent. The scour, however, is not confined to the bottom of the bed in e central part, but is active upon the sides, especially where concave

sides of bends join the bottom. The result is that the deepening or lowering of the bottom of the bed is counteracted by the material falling upon it from the sides. The net result is probably a very little change in the size of the waterway, but a great change in its location as it moves laterally, thus compelling every flood to pass over a path different from those of previous floods.

The enormous energy of a Mississippi flood is therefore applied, not where that of previous floods has been applied, so as to add its effect upon the deepening of the bed to the effects of other floods, but it is applied upon a different path, and largely to the moving of material brought into the bed by previous floods, at the same time it is doing mischievous work in the filling of the bed to obstruct the next flood and consume its energy.

The surveys made by the commission to develop the changes in the bed have been disappointing to some of the members of the commission, as well as to many persons who have been studying the subject. I do not feel any disappointment, for I find abundance of proof of the tremendous lateral movement of the river, and satisfactory proof that there is so little material change in general depth of bed that there is, under present conditions, no need of apprehension that the bed is rising in consequence of levee construction; and, on the other hand, that there is little hope of any material deepening to be obtained through the concentration of flow produced by levees, so long as that concentration of flow is permitted to act upon the banks to pull them down upon the bottom of the bed and fill up any deepening that may have occurred there. With banks protected, deepening would be progressing and probably result in lowering the necessary height of levees and render the maintenance easy and of little cost. The lowering of the low-water surface of 1894 has been referred to as being something of an indication that the extension of the leeves during the immediate preceding years had produced a lowering of bed. This may be so, but I am inclined to think that the lowering of the low-water surface of 1894 was largely due to the tremendous scouring effect of the great flood of 1893, followed by the comparatively high low-water stage of that year, which kept the deepened channels open, into which the very small volume of the flow of the tributaries in 1894 passed.

Now passing to the question of cost of construction and maintenance of levees, I would say that in 1896 the committee on levees submitted to the commission an estimate of the cost of completing the levee system as it was then contemplated to build it. That is, to cover all fronts from Cairo to Fort St. Phillip, with exceptions to be noted, by levees of sufficient height and strength to withstand any flood that might be expected. In making this estimate it was necessary to assume at various points along the river a height to which the flood surface might rise when its entire volume was passed within levees, from Cairo down. In determining or estimating what this height might be at various points was an exceedingly complex problem, which had engaged the serious attention of all of the engineers who had ever been connected with the investigation of the various phenomena of the ever-changing conditions of the river. Taking into consideration all of the available data, representing the work of many able men, and the experience derived from careful observation of previous floods, and the effect of previous levee building, the committee fixed upon heights at various points to which, in their opinion, floods might rise when fully confined by levees. Lines connecting these points gave the heights at all points of the river to which it was estimated the flood might rise,

ıd levees were estimated for to be 2 feet above these lines. While ;reeing with my colleague (Major Harrod) on the committee that it is 'oper and advisable to revise the estimate, I feel that it was fortunate at the destructive flood of 1897 did not develop any serious error in e estimate of expected flood height. At no point did that flood reach at height for which the estimate provides.

I will give you the comparison at the following points from Cairo to e mouth of Red River:

The height to which the committee estimated it would be possible for e flood to reach at Cairo was 54.2. The actual height of the flood of 97 was 51.6, a difference of about 2½ feet. The flood was 2½ feet wer than we expected it might rise.

At Memphis the committee's estimate was 39.6 feet. The height of e flood of 1897 was 37.7; about 2 feet lower.

At Helena the committee's estimate was 52.1. The 1897 flood height as 51.8; nearly up to the estimate, not quite.

At the mouth of White River the committee's estimate was 56.4. ıe 1897 flood height was 52.4; 4 feet lower.

At Vicksburg the committee's estimate was 54.8. In 1897 the flood ;ight was 52.4; nearly 2½ feet lower.

At the Red River the committee's estimate was 53.9. The 1897 flood ;ight was 50.2; nearly 4 feet lower.

Q. Have you got Greenville?—A. I have not. That is one of the ıtermediate places that would come between the mouth of the White iver and Vicksburg.

Q. Then taking Vicksburg and the mouth of the White River as a asis, how would that leave Greenville?—A. I can not make that comarison without calculating the mileage.

Q. Take Vicksburg and Helena, say.—A. You can not figure that ay at all. You would have to take the difference, and then take a proortionate amount of the distance between the two.

But in all cases it will be noticed that the line of flood as estimated y the committee and adopted by the commission was higher than the ood of 1897. The only point where the flood of 1897 approached that ne was at Helena, where it came within three-tenths of a foot of it. ut the flood of 1897 does not establish the standard. It was only a ood which gives us a great deal of information, so that we can revise ıd correct our estimate and make it more nearly approach to what the 'eatest flood height will be when the water is fully confined between e levees; but by a comparison of these figures, it will be seen that in ost places the line, as established by the committee, is from 2 to 3 feet ove the actual flood level of 1897, and the margin is ample for the ;ight a flood may reach if fully confined, with the exception of that .rt immediately in the vicinity of Helena.

Q. You refer to the height to which you estimated floods might likely tain in the future when you speak of your flood estimates.—A. Yes, sir.

Q. Your levee estimate was for a still greater height, was it not?—A. :s, sir; 2 feet above that line. We estimated that the flood at Cairo ght be 2 feet higher than any known flood; then we provided for a :ee 2 feet above that line. Therefore we provided for a levee at iro 4 feet higher than the highest flood that has ever passed there.

Q. Now, with the provision you have made in your estimate (say at iro) for 2 feet higher than any known flood, how much higher would ıt have been than the flood of 1897 developed?—A. The flood of 97 was 51.6; it was not quite up to the flood of 1883. In 1883 it was .2.

Q. How much higher would that make your levee at Vicksburg than the flood of 1897?—A. It would make it 4.4 feet higher than the 1897 water at Vicksburg.

Q. And higher than any previous flood?—A. Yes, sir; except, I believe, in the early days there was a flood height at Vicksburg higher than any other known flood. (To Major Harrod.) In 1862, was it not?

Q. At Helena it would be how much?—A. 2.3 higher than the highest flood that has ever passed, but not 2.3 higher than any flood that we expect.

Q. No, but higher than the flood of 1897?—A. Yes, sir.

Q. Did you take into account in your estimate the complete closure of all the basins above up to Cairo?—A. Yes, sir; the full closure of the line from Cairo down to Fort St. Philip, with certain exceptions which I will note later on. This comparison shows that it would be advisable to raise the estimated line in the vicinity of Helena and lower it near Red River Landing and perhaps at the mouth of the White River. The net change required in the amount of yardage estimated will not, I believe, be very great. But of course a revision of the estimate should be made. The price that the levee was estimated to cost was placed at 15 cents per yard. At the time that estimate was made the committee felt that that was ample, because, previous to that time, when the levees were built under the continuing contract system, the price got so low that in a very large part of the work it was down to 11 and a fraction cents per yard. Afterwards, and especially after this estimate was made, when we attempted to build levees by the yearly appropriation the price went up, and the price this year, and I believe last year, was more than 15 cents per yard. But if there should be a large sum appropriated for levees, so the large contractors (men who handle a large plant and are able to put up a large amount of yardage) could feel confident of having a great deal of the work to do, so as to keep their plant employed, I have no doubt but that the price would come within the estimate.

Q. But do you not think there is likely to be a little more yardage than you estimate?—A. It is possible, but I doubt it. I am certain there would not be any material increase in the yardage; there may be some increase. When I say "material increase," I do not think there could be over 20 per cent; I do not think it would be possible, from what we know of the river and the requirements of such work.

Q. Not over 20 per cent increase?—A. I would say that that is an outside limit for the increase in yardage.

Q. Assuming that the cost was 15 cents per yard; at 20 per cent increase, how much would it run up to?—A. That would run it up about three and one-half million dollars more.

Q. That would make it $21,000,000?—A. Yes.

Q. Or nearly $22,000,000?—A. Yes, sir. But I question that. I do not think it would amount to that.

Q. But would it not, in your opinion, amount to at least twenty millions?—A. I do not see any very good reason, from the figures we have now, for increasing the estimate at all. There is quite a stretch of river where I think we can lower that line. The only point where we may have to raise it is in the vicinity of Helena.

Examined by Mr. BERRY:

Q. Why, in your opinion, was there less difference at Helena in 1897 in the estimated height than at other points?—A. I think it was due to the closing of the White River front and the work in the St. Francis front.

Q. You think those two causes made a less difference at Helena be-
reen your estimated height and the height attained, than anywhere
se?—A. Yes, sir.
Q. I will ask you if you do or do not think that the return water
om the St. Francis Basin, joining the flood above Helena at the mouth
the St. Francis River, increased the water level at Helena.—A. It
iquestionably increased it.
Q. The two coming together at Helena made the water higher at
elena?—A. Yes, sir.
I stated that this estimate was made upon the levee system as it was
tended to build it from Cairo down of a sufficient height and strength
withstand the greatest flood that could be expected, leaving out cer-
in small basins, especially down below Vicksburg. It has never
en contemplated by the commission to include the leveeing of the
ont of those small basins in any estimate for levee building. Now it
ay in the future be a question as to whether or not those levees should
built. If it is decided that they should be built, then that will be
addition to the estimate that has been prepared.
Q. But that would only affect the river below, would it not, mainly?—
. Yes, sir. I refer to those small basins from——
Q. One is the Lower Tensas, is it not?—A. No; it is on the other
de, near the hills. From Vicksburg down to Baton Rouge.
Q. Oh, yes; several basins there? A. Very small areas, where tribu-
ıry streams come in. As a general thing, the high ground and bluffs
pproach the river very closely above Memphis, and there is only a
ery little levee work to do above Memphis, on the east bank of the
iver, and there is nothing included in the estimate for any levee work
here in those small basins. If it were decided that those should be
ıcluded, that would be in addition to the estimate that the committee
as presented.
So much for the cost of construction. Now comes the question of the
ost of maintenance.
The levees that have been built on the river in past years (as has been
estified to by a number of people) were located for various reasons,
one of which contemplated the very long life of the levee. The idea
f the commission latterly—since they have entered so actively into
vee building—has been, where it is possible, to have levees so located
ıat they should not require reconstruction within twenty years. The
istrict officers in carrying out that intention have not always been able
locate their levees in that way. There are often many reasons why
ıey could not do it, and therefore the levee lines as now constructed
e not, in a great many places, in locations where they will require
construction in less than twenty years.
You may say that the whole line of levee will have to be rebuilt
ery twenty years—that is, 5 per cent each year would have to be
built. It was stated in the testimony of someone, to-day or yester-
ıy, that it is probable that only one side of the river would require
at reconstruction in twenty years, because there was only one side
at was in the bend; that the other side was on the point, and that
the point side the levees were not injured. But we must remember
at what is now the bend side in ten years from now may be the point
de, and what is now the point side in ten years from now may be the
end side. The bends are continually traveling down the river. One
de of the river is in a bend at one time and at another time it is on a
oint. So, where you are considering the permanence of a system, I
ink it is only proper to consider that both sides are subject to destruc-

tion from the action of the river itself, provided nothing is done to prevent that destruction. Therefore I would say that a rough approximation of the cost of maintenance of levees would be somewhere in the neighborhood of 5 per cent plus what would be necessary to keep them from deteriorating from the effects of the weather gullying them out, from the effects of cattle moving around on them, from the growth of trees and shrubs that sometimes have to be removed, and sometimes the scouring of the current gouges out the earth. That is a small matter as compared with the replacing of levees that have caved in. However, I think a very rough figure for the cost of maintenance would be 5 per cent.

Mr. CATCHINGS. Instead of stating it in percentages, Colonel, what would you estimate that 5 per cent as amounting to in dollars and cents?

The WITNESS. The only way I could answer that would be to take 5 per cent of the entire yardage of the complete levee system; then take the 5 per cent of that entire yardage, and multiply it by the cost per yard at the time the work was done. Sometimes it might cost 15 cents per yard and sometimes 20 cents. The only way I could arrive at it would be to compute it at the present price or at the price considered in the estimate—15 cents per yard.

Mr. CATCHINGS. You would not take that per cent from what the levees have cost up to date, but only on their value as completed?

The WITNESS. Not what they would cost up to date, but the amount of yardage there is in them when completed to their full height and strength.

Examined by Mr. NELSON:

Q. In other words, there will be in round numbers about 1,500 miles of levees when the system is completed?—A. Yes, sir.

Q. And assuming each linear mile of levee to have the same quantity of yardage as every other linear mile, it would be 5 per cent of that distance?—A. I think that would be a rough approximation of it.

Q. Assuming the body of the levee to be equal for the 1,500 miles?—A. Yes.

Q. It would be equivalent to about 75 miles each year?—A. Roughly; yes, sir.

Q. It would be equivalent to the replacement of 75 miles of levee per year on the distance of 1,500 miles?—A. That is, taking the life of the levee at twenty years.

Q. And that would amount to how much, approximately? What is the average cost of a mile of levee?—A. That, of course, varies with the height of the levee.

Q. I know; but taking the average, the best you can give us—a rough estimate?—A. I should say somewhere between $10,000 and $15,000. I would not like to say offhand.

Q. Per mile?—A. I would rather not say that offhand. I would not care to put a figure of that kind down without considerable study of the matter.

Mr. GALLINGER. Colonel, if I may be permitted to interrupt you right there, will it not cost for maintenance one-twentieth of the entire cost of a completed system, estimating it at the price paid per yard at the present time?

A. I do not think that would be quite the right estimate. The cost, as nearly as I can state it, would be the whole number of yards in the completed system divided by twenty, multiplied by the cost per yard.

Mr. GALLINGER. That, of course, would give it with absolute accu-

acy; that is a mathematical calculation. But would not my statement pproximate the amount very closely?

A. No, sir; that would not be a correct estimate of it.

Q. Let me see if I get your idea. There will be 1,500 miles of levee hen the system is completed. For replacement, assuming each mile f levee to be equal to every other mile, 5 per cent would be 75 miles a ear, would it not, to be replaced?—A. Yes, sir.

Q. And assuming the cost to be, say, $15,000 a mile, that would ake it $1,125,000 per year, would it not?—A. Yes, sir; on that basis.

Q. That may not be exact, but on such theory as that the estimate ould be made, would it not?—A. The estimate would actually be made pon the actual number of yards of earth in the new levees that you ut in, and you can not estimate it by miles, because your assumption ould not be right that one mile is the same as every other mile. In he height of the levee and the cross section you can not make that ssumption at all, because the levees vary every mile, or even every undred feet.

Q. No; it would not be an accurate assumption; I con de that, but per cent of the levees would have to be replaced in each year. That s a rough approximation?—A. Yes.

Q. So it would probably cost $1,000,000 a year, at least, for mainteance?—A. Probably.

Mr. GALLINGER. If it is going to cost $20,000,000 to complete it, it would cost $1,000,000 to take care of the additional system. Let us be ccurate.

Mr. NELSON. I mean for the maintenance of the levees only.

Mr. GALLINGER. According to the testimony of these gentlemen, who have made a study of this question, it is going to cost $20,000,000 to omplete the system. Five per cent of that is $1,000,000. But you ave all the levees now constructed to take care of likewise. I do not now what that amounts to, but it must be nearly as much more, is it ot?

The WITNESS. I do not think I quite get your idea on that.

Mr. GALLINGER. You estimate that it will cost about $20,000,000 to omplete the system. Now, if the cost of maintenance of that system mounts to 5 per cent a year, that amounts to a million dollars, does not?

The WITNESS. Yes, sir.

Mr. GALLINGER. And you have to maintain the levees already built?

A. The yardage that is already in place—yes, sir.

Q. So it is safe to assume that the cost of maintenance, upon your asis of 5 per cent, would be about two millions per year, is it not?—. A little over $2,000,000. That is, to maintain the levee system in he same degree of efficiency, same height and size.

Mr. GALLINGER. How much do you make it?

The WITNESS. About two million and a quarter every year.

Mr. NELSON. For maintenance?

Mr. CATCHINGS. That is upon your estimate that the life of a levee only twenty years, is it not?

The WITNESS. Yes, sir; that is the assumption upon which that stimate was made.

Now the next point is the source from which the money could be btained and the advisability of levee building.

I do not know that that is a question that fairly comes before the Iississippi River Commission. It is rather one that belongs to the legis-

lative branch of the Government; but perhaps an opinion will not be amiss.

In the first place, with regard to the advisability of levee building, as I have stated before, it seems to me, from all the testimony that has been taken, there is no question that the only practicable method of protecting the Lower Mississippi Valley from destructive floods is by a system of levees of sufficient height and strength to contain any flood that may be expected to come down the river. Without these levees (as has been testified to) the people inhabiting this valley will be subjected to great losses annually; the development of the country will be retarded, and the material prosperity of the whole lower valley, and of all that part of the country having business relations with it, will suffer.

I conceive that there is no one (in view of the facts that have been presented to you) who would say that it is not desirable to build levees, provided there was money for it. But, as we have seen by the figures that have been presented, it requires a very large sum of money—a larger sum than the people have been able to raise themselves. They have raised a great deal of money and are continuing to tax themselves as much as possible; and it seems to me that it is a fair object for the expenditure of the national money when it concerns not only such a large part of the country directly, but a much larger portion of the country indirectly; and without the assistance of money from the National Treasury it is almost hopeless to expect that this complete system of levees that we have estimated for can be built. But, as I said before, that is simply an opinion, and I do not suppose it is a matter that the commission has to deal with.

Now comes the question of ownership and control.

I suppose the committee has been impressed by the entire agreement of all the people who have been examined that it would be a good thing for the United States Government to take control of this work and own the levees. There are certain very great advantages in the Government taking charge. It seems to me there are also some counterbalancing disadvantages in Government ownership. There are many questions that will come up in the future with regard to the building of these levees. One of those questions is that of damage to those who have not been protected by levees or not sufficiently protected, and I imagine those damages are going to be heard from from a great many parts of the country that you have not heard from yet. I believe it will not only come from those parts of the immediate valley of the Mississippi River which have not been protected (like these small basins below Vicksburg), but it will also come from the country down through the Atchafalaya and the Teche districts.

In a printed communication that has been distributed here there is a reference to the fear that the Mississippi River will go down the Atchafalaya and flood that country. I would suggest, as a matter of opinion, that it seems to me it would be a good idea for the Government to take charge of this work of building the levees, assisted as much as possible by the local authorities, because, in the first place, the work would be done, and in the next place it would inspire so much confidence in the people themselves that it would induce very much greater efforts on their part, so that the work could be done more quickly and afford quicker relief. After the levees are completed, it seems to me it would be a very good idea for the Government to turn them over to the States through which they run and let the States then assume all damage that may result to parties who are not benefited by the levees by equalizing

the difference between those who are benefited and those who are not benefited. Let those who are benefited by these levees help their poor brothers who are drowned out. And when the United States has finished this work (built the levees under its control) then turn them over to the States and have nothing further to do with the matter.

Mr. NELSON. Let the States maintain them?

The WITNESS. Let the States maintain them.

Mr. NELSON. And attend to all questions of damages?

The WITNESS. That would be my idea.

That is as far as I have anything to say upon that branch of the subject. I have something to say about some other things.

I would say that I, for one, was very glad to notice in the newspapers hat a bill had been introduced in the House of Representatives, by Mr. Catchings, for an appropriation by the General Government for the purose of building levees for the protection of the people of this valley rom floods. I believe that puts the work squarely on the foundation here it belongs. Levee building by the Government heretofore has een a part of the work of the improvement of the Mississippi River.

I will read a portion of the law organizing the commission, which sets orth the duties of the commission:

It shall be the duty of said commission to take into consideration and mature such lan or plans and estimates as will correct, permanently locate, and deepen the hannel and protect the banks of the Mississippi River; improve and give safety nd ease to the navigation thereof; prevent destructive floods; promote and facilitate commerce, trade, and the postal service.

Now, the construction of levees evidently has some connection with hose duties of the commission. It seems to me that in the improvement of the Mississippi River there are some other questions that arise, which are perhaps of equal importance or of greater importance than hat. That is one branch of the subject. It is only one part of the problem. I will say that I have been somewhat at variance with some of the other members of the commission with regard to the carrying on of the works of the river. The policy of the commission was definitely stated a year or two ago, to give up all permanent work on the river, except at certain points, and to confine the attention of the commission to the building of levees and the temporary work of improving channels every year.

Q. By dredging?—A. By dredging. That was not especially mentioned as being the way, but that was the intention—to do it by dredging.

I found myself so much at variance with the other members of the commission that in 1896 I wrote a minority report upon the subject, and as that report expresses my views upon this subject perhaps better than I could give them offhand and without considerable study and preparation, I would like to read you the report:

Not concurring in some of the statements, conclusions, and recommendations contained in the above report, and believing that the continuance of the work of the commission along the lines laid down is a radical departure from the pursuit of ome of the principal objects for which the commission was organized, and that the irtual abandonment of the great work of the permanent improvement of the Mississippi River, after the expenditure of a vast amount of money, will be a great disppointment to the whole country, and will finally result in leaving the river in bstantially the same unsatisfactory condition that it was at the beginning of the ommission work, I deem it proper to express some view at variance with the above port.

The act of Congress organizing the Mississippi River Commission set forth a part f its duties in the following words, viz:

"It shall be the duty of said commission to take into consideration and mature ich plan or plans and estimates as well correct, permanently locate, and deepen he channel and protect the banks of the Mississippi River; improve and give safety

and ease to the navigation thereof; prevent destructive floods; and promote and facilitate commerce, trade and the postal service."

There can be no question that the act contemplated the attainment of at least four distinct objects, that is: The permanent fixing of the water course, the permanent improvement of navigation, the permanent protection of landowners against loss of life and property by its bodily removal by the river, and the permanent protection of the people in the Mississippi Valley against loss of life and property by the river's overflow. These, surely, one and all, were great objects to be attained and worthy the attention and powerful aid of the General Government.

In no subsequent act has Congress modified the duties of the commission to the effect that efforts looking to the permanent improvement of the river should be abandoned.

In the act of Congress of June 3, 1896, the commission were directed to expend such sums as might be necessary for the construction of suitable dredge boats and other devices and appliances, and in the maintenance and operation of the same with the view of obtaining and maintaining a navigable channel.

This provision of Congress undoubtedly requires that all efforts should be made toward the immediate improvement of the channel for navigation, and certainly contemplates the use of devices, dredges or other devices, which may not be regarded as belonging to any system of permanent improvement; but the act does not require nor imply that permanent improvement, to accomplish all of the objects of the original act, shall be regarded as hopeless, and therefore all work in pursuance thereof abandoned. The recent agitation, by those interested in the navigation of the river, in favor of immediate improvement of the channels, even though such improvement be of temporary character, was the natural result of the impatience bred of the cessation of that part of the commission's work that looked to ease and safety of navigation, and should be met by such efforts as are possible to provide for immediate relief, while the work for the permanent and more comprehensive improvement is being steadily pushed forward.

The building of levees without bank protection may be considered as only temporary work, undertaken for the purpose of giving immediate relief from the disastrous effects of unrestrained floods, both in the matter of overflow and, to some extent, channel deterioration; but nearly every yard of these costly structures, upon which millions of dollars have been spent, will sooner or later have to be rebuilt, if the river is permitted to wander back and forth in its valley, annually carrying off hundreds of acres of land, tearing down levees, and filling up its own bed, thus continually adding to the obstructions to navigation and impeding the flow of floods.

In attaining the principal objects of a permanent improvement of the river it is now a pretty well settled fact that three classes of work are required, viz: The protection of banks from erosion, the regulation of low-water channels, and levee building to prevent overflow. Of these, by far the most important to all interests involved is the work of bank protection, and it is the foundation upon which all other work of permanent improvement must rest.

When it is considered that surveys have shown that about 1,000,000,000 cubic yards of earth are torn out of the banks of the river each year—that is, over 9½ acres, 66 feet deep for each mile of river—it is certainly not to be wondered at that bars obstruct navigation, that the people of the valley lose immense areas of their finest land, that levees have to be constantly rebuilt, that floods can not find room to pass, and that the channel at the mouth of the river leading to the sea is constantly filling up. It does not require any great stretch of the imagination to suppose that the tremendous amount of energy of the river now consumed in work of devastation would, if properly controlled and directed, so deepen the bed and regulate the flow as to largely diminish the number of obstructive bars and increase the flood capacity, thus lowering flood heights and rendering levees of less importance and their maintenance a matter of small cost, while at the same time protecting the property of riparian owners and year by year rendering the stability and permanence of the levees a matter of greater certainty.

In the recent allotment by the commission of the large sum of $9,000,000, nothing is set aside for this most important of all work, the protection of the banks, and it is stated in the report that it is the general recommendation of the commission now that there shall be no further work undertaken for the permanent improvement of the channel until extensive experiments are made in the line of temporary improvements by dredging. This, taken in connection with the allotment of the funds and provisions of Congress for the next four years, means that at least for that length of time no work shall be done looking to permanent improvement.

The report assumes that the cost of bank protection from Cairo to Vicksburg would be $63,000,000; that the annual cost of maintenance would be over $6,000,000, and that the time required to do the work would be forty years. I can not assent to these estimates. They are assumptions based upon a certain form of bank protection—the only form which, during fifteen or sixteen years, has been exhaustively

experimented with, and which, having grown in cost from $11 to $12 per linear foot of bank to $30 per foot, and requiring the complete covering of every square foot of caving bank, is now so far from perfect that no one has complete confidence in it. Besides which it is composed of materials of which the supply is limited, and it is estimated that each year 10 per cent of its original cost must be expended to maintain it.

Having reached this result, it would appear proper now to look for other forms of bank protection, instead of abandoning the most important work confided to the commission. Every effort should be made, and made without ceasing, to solve the great problem upon which depends final success in attaining the great objects for which the commission was formed.

What will it profit the planter to have the overflow water kept off his fertile acres for a year or two if the remorseless river is to take his plantation bodily away from him? How much will the danger and anxiety of the thousands of people who live under the protection of the levees be lessened by the continual raising of the flood heights, which the extension and building up of the levees is known to cause, with no steps taken to counteract such raising?

How can it ever be expected to reduce flood heights as long as the river forces are permitted to dam up the waterway by pulling into the river bed each year an average of 9½ acres of ground, 66 feet deep, for each mile of river? What hope can the navigator have of ever reaching safety and ease and certainty of navigation if his only reliance is to be on channels cut out by machinery, which are liable to fill up at any time?

I do not wish to be understood as discouraging all proper efforts for the immediate, even if temporary, improvement of navigable channels. Such efforts should be made by dredging and by other devices.

Neither do I wish to be understood as opposing the policy of levee construction, which I believe to be one of the important parts of the whole work of river improvement. But I deplore the abandonment or the postponement of the work of fixing the river in its channel, a part of the whole work of improvement which, in my opinion, outweighs all other work—makes other work effective, and to which a large portion of the available funds should be devoted.

That is the stand taken by me upon this question of improving the river, and it is exactly in accordance with the early ideas of the commission, who gave very exhaustive study to the forces at work, the manner in which the river was deteriorating, and what might be done to put it in navigable condition all the year around. The commission worked in that line until a majority became discouraged with the cost and, therefore, concluded to drop that part of the work. As I have stated, I think it is the most important of all the work on the river.

Examined by Mr. VEST:

Q. If you had $20,000,000, how would you apply it?—A. What would be the title of the appropriation, Senator?

Q. Well, it would be $20,000,000, adopting the same language used in the original act.—A. To improve the Mississippi River?

Q. And prevent destructive floods, and such matter.—A. The same as the organic act?

Q. Yes.—A. If you will permit me, I will read again what the duty of the commission under that organic act is: "To take into consideration and mature such plan or plans and estimates as will correct, permanently locate, and deepen the channel, and protect the banks of the Mississippi River"—that is not all; that is the first part of their duty as laid down in the act—"improve and give safety and ease to the navigation thereof, prevent destructive floods, and promote and facilitate commerce, trade, and the postal service." That is what the commission was organized to do.

Q. Now, suppose you could only get $20,000,000; what would you do with it?—A. If I had $20,000,000 I should devote $10,000,000 of it to the fixing of the banks of the Mississippi River, as far as it would go, commencing at some point just above Cairo. I would expend about $5,000,000 on temporary devices.

Q. Now, what is a layman to do? Colonel Gillespie says if he had that amount he would distribute it differently. What are we to believe (we are not experts) when you scientific men disagree?—A. Well, of course everybody has a different opinion from everybody else. Two men scarcely ever agree upon anything.

Q. Well, what is going to become of those of us who have to go to you for an opinion? Here we come to a commission organized to study this question and to tell us what to do, and you differ so radically that it is impossible for us to decide the matter.—A. Well, I think, Mr. Senator, if you will look into the earlier reports of the commission you will find that the question of the improvement of the banks by revetment, so as to keep the river in one place, was considered to be one of the most important of all the questions that came up in the problem of the improvement of the river. They abandoned that recently on account of the cost, because it costs a great deal more money than was originally estimated. Now it seems to me that, while we may not be able just now to do this work as it should be done, within a low limit of cost, what we ought to do at present in getting for the immediate future is to find how we can do it within a reasonable limit of cost.

Examined by Mr. GALLINGER:

Q. Just there. Colonel Stickney, it has come to my attention in some way that experiments have been or are being made, or contemplated, to reduce the cost of the so-called revetment of banks. Do you know anything about that?—A. Protection of banks, I suppose you mean?

Q. Yes.—A. Yes, we are making experiments upon a device that I had planned on the Missouri River; but I did not have reference to that particular device in giving this testimony. What I mean is that we ought to work at this thing until we find some way of protecting the banks within a reasonable limit of cost. If this device turns out to be satisfactory at a reasonable cost, it will be a good thing to adopt; if it does not, we must try something else.

Q. In that same connection, would you state, for the benefit of the committee, of what that device consists? In what respect does it differ from the present established and expensive mode of protecting the banks?—A. The main difference is that it contemplates the protection of points of the bank, instead of the whole length of the bend.

Q. You protect the salient points of the bank, where the water would naturally make its attack, instead of continuing the revetment along the entire bank as a complete system. Is that the idea?—A. In the Mississippi River, especially the lower river, the water flows generally in large bends, first in one direction, then crossing over and reversing. The bank that is eroded by that water is on the concave side. The convex side usually builds out as the concave side caves. Those bends on the Mississippi River are sometimes 2, 3, 4, and 5 miles long. Now the idea I had conceived was to protect points along that bend, at such distance apart as experience should show to be proper, and leave the rest of the bank alone. It could cave for a short distance and then could not cave any farther, because the river would have to follow its general course.

Q. Have you made any practical test of this device, or is it still in an embryotic state?—A. We have been building a number of them in the Missouri River during the past year.

Q. How much would that reduce the cost of bank protection as compared with the established system?—A. If that particular device proves to be successful, as planned, it would reduce the cost 75 per cent or more.

Examined by Mr. CATCHINGS:

Q. Colonel, what was the estimate to which you have alluded as having been made by the commission to revet down to Vicksburg?—A. The estimate of the cost of revetment?

Q. Of this bank protection, from Cairo to Vicksburg.—A. $63,000,000.

Q. And the estimate was that it would take forty years to do it?—A. Yes, sir.

Q. If you believe it to be true that it would cost that much, and would take that long to build, would you proceed to do that work if an appropriation of $20,000,000 were made? Would you spend the $20,000,000 in the prosecution of that work?—A. If I believed that that work was substantial and would hold the bank for all time I would conceive that it would be proper to carry that work on as rapidly as the Government would furnish the money.

Q. Even if it took forty years to do it?—A. Well that, you know, is a thing that I do not assent to. I do not assent to that at all.

Q. Well, I was putting the question to you upon the assumption that you did assent to it. If you did assent to that; if you believed it would take forty years to do it, would you proceed upon those old methods of bank revetment?—A. I think that if I were confined to one form of engineering work and was not permitted to change that form, and I knew that form was not effective within a reasonable cost, I certainly would not undertake it.

Q. Then am I to understand that you would not proceed under the old system of bank revetment if you thought it would cost $63,000,000 and would take forty years to do the work?—A. And cost $6,000,000 a year to maintain it?

Q. Yes.—A. No, sir; I do not think I would.

Q. Then you would approve the abandonment of that plan at all events?—A. I would approve the abandonment of that particular method of protecting banks.

Q. You have stated what your device would be for bank protection. Now, if $20,000,000 were appropriated, with the limited experimentation which has taken place with your plan, do you mean to say that you would at once go to work to expend $10,000,000 upon your device without making further experiments?—A. No, sir; I think I would not.

Q. Then, if $20,000,000 were appropriated, you would only expend so much of it in putting down your device as would enable you to determine, as an engineer, whether it would be effective?—A. I think I would put down a good many devices.

Q. Of course, enough to make the experiment complete. So you would not, then, immediately expend $10,000,000 in putting down your device?—A. I would not put down any device that I was not satisfied would do the work that was required of it.

Q. And it would not require $10,000,000, or anything like that sum, to make the experiment?—A. No, sir.

Q. And you would not embark upon so large an expenditure, of course, until you had fully satisfied yourself that you were expending the money properly?—A. I would not.

Q. So your answer to Senator Vest's question must be taken with that limitation.—A. Yes. But at the same time I would expect to put that money upon some device for the protection of the banks.

Q. You would not withhold that money from expenditures in other directions—— —A. If I were given $20,000,000 to improve this river and I did not know that any other was coming in years, I should cer-

tainly hold that money until I found a device which would accomplish that object.

Q. With that sum?—A. With that sum.

Q. And that device you probably would never find.—A. I do not mean a device with which you could improve the whole river with that sum. I would carry it as for as it would go.

Q. But you said if you had that sum and knew you would never get any more, did you not?—A. No; I said, I think, if I did not know whether I was going to get any more or not.

Q. Then you would be likely to hold it until you did know, would you not? You would not enter upon the partial expenditure of that money unless you knew you could carry the matter to completion, because you would not know but what it would be thrown away.—A. Well, I would just hold that money. I would not put it in other things, because if I did, when the work was begun, I would not have any money to do any work with at all.

Q. In other words, looking at the question as you do individually, you are not now prepared to say that the work of bank protection could be carried on under such an economical system as would be likely to meet with Congressional approval?—A. No, sir, I am not.

Q. You would not proceed according to your method of revetment?—A. I think not. But I will say this, that I would constantly work toward developing some plan of bank protection that would be permanent.

Q. As I understand, you place very great, I might say intense, value upon bank protection?—A. Yes, sir.

Q. And, valuing it as you do, you would persist in making experiments until you had hit upon a plan which would work?—A. Yes, sir.

Q. And that is all you do mean to say. You do not mean to say that you are at this time prepared to expend $10,000,000 upon bank protection?—A. I would not expend it until I could put it upon work that I thought there could be some dependence placed upon to accomplish the object.

Q. And you would simply continue your experiments until you had satisfied yourself?—A. Certainly.

Q. Have you any suggestions to make as to bank protection, in addition to what you have stated?—A. I would like to say that, in addition to the work I am doing now in attempting to evolve some better and cheaper plan of protection, there is going on under the commission other work upon the plan of protection that was used in New Orleans Harbor, called spur dikes. Captain Derby, of the Fourth district, is now putting in such work in the Giles Bend, which, so far as he has gone, has cost less than 30 per cent of the continuous revetment, which has been estimated at $30 per foot. His work, as I understand it, has been done at the rate of $12 per foot. Am I right about that figure?

Captain DERBY. Ten dollars a foot for this season's work.

Q. Would it be your idea then to substitute this spur-dike work for the old revetment work that you have been resorting to?—A. I should not until it has been more exhaustively tried.

Q. But you believe it is a system that ought to have a complete trial?—A. Yes, sir.

Q. And you believe it has great possibilities?—A. I do. There were some spur dikes put down in New Orleans Harbor in 1884. I put the first one down when I was in charge of that district; that I believe is intact now and is doing perfectly the work that was expected of it.

Q. Are you applying any of that work on the Missouri River anywhere?—A. Spur dikes?

Q. Yes.—A. Not of that kind; no, sir.

Examined by Mr. VEST:

Q. Colonel Stickney, you called my attention to the organic act, and especially to the fact that the first instruction to the Mississippi River Commission in the organic act (and you laid considerable stress on that act) was the strengthening of the banks of the river. That is so, is it not?—A. "To protect the banks of the Mississippi River."

Q. Now, I call your attention to the act of 1896, which says nothing about strengthening the banks of the river, but makes the whole appropriation for the purpose of the general improvement of the river, building and repairs of the levees, and to a survey from the passes to the head of the river. I call your attention to the fact that what you laid so much stress on is eliminated entirely in the act of 1896.—A. No, Senator. The phraseology of appropriation acts is very generally different from the phraseology of an act that organizes a commission and says what it shall do. The appropriation act, in the first place, starts out with "for the improvement" of the river. Now, what does that mean?

Q. In the other case, that you laid so much stress on, it was for the strengthening of the banks of the river, and you said that because that came first, it showed it was the principal object of the act.—A. No, I do not mean to say it was the principal object, but one of the first objects.

Q. And you called my attention to it, and said, "This is the first part." Now, how does it happen that the first object is left out of that appropriation bill if it is of so much importance?—A. I do not know that I feel at liberty to say exactly what I think the reason was.

Q. I can tell you why it was. I was on the Commerce Committee; I have been ever since I have been in Congress.—A. I know there were very strong sentiments along the upper river, especially in the vicinity of St. Louis, with regard to the immediate improvement of the channel, and a party of men formed there a company, and went to Congress with the idea of getting a contract to do that work of temporary improvement of the river at a pretty large sum of money. They were influential men, men who had, I have no doubt, the improvement of the river at heart, and they were backed by men who were very much interested in it. I think that those people made a very strong impression on Congress as to the possibility and advantages of doing that work. Some members of the commission were called before Congress and interrogated in regard to it, and also in regard to what an estimate of the cost of that kind of work would be. And some of the members of the commission, or at least one, I know, made an estimate of what it would cost to do that temporary work, and Congress decided to afford that immediate relief by dredging the river.

Mr. VEST. Well, you are entirely mistaken, Colonel. I recollect all about that. Webb Samuel came on there with a project of that kind, which was never contemplated seriously by anybody except himself and his associates. And I want to say to you now, Colonel, as a member of that Commerce Committee (and I think every man who was on the committee then will agree with me) that we never had any idea of appropriating money to make revetment of banks the principal object.

The WITNESS. Well, I do not know, of course, anything about what the intention of the committee was. I only know that the law organ-

izing the commission made that the duty of the commission; and I also know that when the commission took up this subject of the improvement of the river one of the first things, and the main thing, to do was to locate the river permanently in one place, to keep it from wandering back and forth, for without that you could not put in any contraction works in the river.

Mr. VEST. Nobody wants to minimize the importance of that work, but if we can not get the money to do it, we want to do the next best thing. You tell us it will take $120,000,000 to revet the banks from Cairo to the mouth of the Red River. Now, that is a very considerable amount of money, and suppose we can not get it, are you going to let the river remain in the condition in which it is. and drive all these people out? That is the serious point. It is not what is theoretically best or what anybody thinks should be done if we had an unlimited amount of money. We are here as practical men, trying to see what we can do with the river with such means as we can command.

The WITNESS. I understand that. Now, if Congress intends that a certain class of work shall not be done, and that another class of work shall be done——

Mr. VEST. That is not the question I put to you. I asked you if you only had $20,000,000 (and I took that amount because it was the estimate made by Major Harrod as to the amount necessary to complete the levees from Cairo down to the mouth of Red River) what you would do with that amount—not $120,000,000, but $20,000,000—and you answered me that you would put $5,000,000 only on levee work, $10,000,000 on revetment, and the balance on general work. I deprecate very much the fact that your commission can not agree on this matter, because it would strengthen us very much if we could go back with a general concensus of opinion.

The WITNESS. I am giving you in that regard my engineering opinion as to what I think ought to be done.

Mr. CATCHINGS. I understand you would not proceed with the old plan of bank revetment?

The WITNESS. I would in certain points.

Mr. CATCHINGS. I mean for the general improvement.

The WITNESS. For the general improvement I do not think I should. I should try to invent some other plan by which it could be done for a great deal less money.

Mr. CATCHINGS. And in your judgment the commission ought to proceed with its experimentation until it gets a plan by which that could be done?

The WITNESS. Yes, sir.

Mr. NELSON. Have you anything more to say, Colonel?

The WITNESS. In view of the discussion that has come up here as to the meaning or intention of the act, I would like to say this: As a member of the Mississippi River Commission, I conceive it to be my duty to do what I deem is for the best of the works; that I am to use my influence, my vote, my position as a member of the commission, in doing that which I think is best for the general improvement of the Mississippi River. And whether it is levee building, or bank protection, or dredging, or anything else, I feel that it is my duty to assert my opinion about that in all matters that come before the commission. And I do. Now, whether I am wrong with regard to the construction of the law or not, I do not know. If the law compels me to abandon the protection of the banks of the river, very well.

Mr. NELSON. It does not compel you. There is no such law.

Mr. VEST. Nobody said there was any such law. What is the use of making an assertion of that kind, as if somebody had said there was?

The WITNESS. No; I do not say there is any such law.

Mr. VEST. Well, the chairman says that, and it puts some of us in a false position, who questioned your position when you read that organic act and said that the first thing it required and the material thing was revetment. I then called your attention to a subsequent appropriation act which did not say anything about revetment (so as to weaken the force of your contention), but in which it is said that you have unlimited discretion to do anything for the improvement of the river.

The WITNESS. Well, I did not see how the phraseology of that later law, for the general improvement of the river, took away the force of that organic law.

Mr. VEST. If you had $20,000,000, what would you consider it your duty to do with it? That is the question.

The WITNESS. I would say in regard to that, that it is hard for any man to answer a question like that without any preparation. We deal with appropriations as they are given to us. The Mississippi River Commission knows nothing about what money is going to come in the future. Congress says we shall have so many million dollars this year, or so many million dollars for a term of two, three, or four years, as it sees fit. Now, that is all the commission knows; they do not know what Congress will do in the matter of appropriations.

Mr. VEST. I would not be absurd enough to imply that you had the power of prophesying as to the amount of appropriations——

The WITNESS. But I wanted you to understand my position.

Mr. VEST. I just want to put this question to you: What is your opinion as to the proper improvement of the river, and what is the most important thing to be done?

The WITNESS. The way you asked that question, Mr. Senator, was this: What would you do with $20,000,000? Now, if a large sum of money like that were given to a man it would require a great deal of time and very careful consideration before he could state his idea of the best manner of applying that particular amount of money. To answer it offhand you would only answer it according to the idea that happened to come into your mind.

Mr. VEST. Well, you have known for some time that we wanted to get at that matter. That question has been put repeatedly.

The WITNESS. Well, as near as I can answer it offhand, the reply I have given is the only one I can make.

Major HARROD. I have been put in the position of one of the majority who recommended the abandonment by the Government of the revetment of the Mississippi River. I do not find that position comfortable, and I do not understand that that was the position that the majority occupied. Personally, I agree substantially with the statement made by Major Dabney, which was a plea for revetment. As to their importance, I agree in many things that have been said by Colonel Gillespie and by Colonel Stickney. But the position a part of the commission took on that question was this: We had started out in the early days, under instructions from Congress, and we had made estimates in our experience at that time.

Subsequent experience proved to us that those estimates were altogether too small. I then regarded it as my duty to inform Congress of what we had learned, and lay before them a revised estimate, and so put them in a position to decide whether to go on with this permanent work or not, as they saw fit. I would be delighted at any time to

receive an intimation to go on with the permanent improvement of the river, but I am waiting for that from Congress. I thought it our duty to lay before them the information in regard to the cost, time, and material that we had acquired by the experience of fifteen years.

Mr. NELSON. Do you understand that the subsequent action of Congress has been to the effect that it has ratified your action in substantially abandoning revetment work?

Major HARROD. Our reports show that to undertake that revetment work would require a very much larger appropriation. Such an appropriation has not been made. I have regarded that Congress has not taken a favorable view of the commencement of the permanent rectification of the river.

Mr. NELSON. Then it is your opinion that Congress really contemplates that about all the appropriations shall be devoted to levee building?

Major HARROD. No; I should look at it in this way: That as long as the appropriations go on with substantial regularity and size, I shall understand that Congress, through that means, has expressed its satisfaction with what we have been doing.

Mr. CATCHINGS. I think you put the case too strongly, anyway, Mr. Senator. I was about to say what perhaps you do not know (if you do I am sorry to interrupt you), that of this $9,000,000 which was appropriated, about one-half (probably more than one-half) was applied by the commission to other purposes than levees. So they have not, by their very action, shown that they regard it as all devoted to levees.

Colonel GILLESPIE. These allotments are, of course, made by a majority vote. The amount was $9,000,000 for expenditure, and $4,500,000 was appropriated for levees.

Mr. GALLINGER. One-half?

Colonel GILLESPIE. One-half for levees, outright. Then $1,120,000 was reserved; that money can be taken by a majority vote for any other purpose at any time.

Mr. GALLINGER. So that, up to the present time, you have used a little over $3,000,000 for purposes other than the building of levees?

Colonel GILLESPIE. Yes, sir.

U. S. S. MISSISSIPPI, *February 7, 1898.*

GEORGE McC. DERBY, sworn, testified as follows:

Examined by Mr. NELSON:

Q. What position do you occupy?—A. I have charge of the fourth district of the Mississippi River under the Mississippi River Commission.

Q. You are a captain in the Engineer Corps of the United States Army?—A. Yes, sir.

Q. From what point to what point does your district extend?—A. From Warrenton, about 7 miles below Vicksburg, to the Head of the Passes.

Q. How long have you been engaged in work on the Mississippi River?—A. A little over three years.

Q. Have you investigated the matter of the flood of 1897 and prior floods?—A. Yes, sir; to some extent.

Q. And have taken pains to compare the flood of 1897 with other floods?—A. Yes, sir.

Q. What was the difference in the high-water stages in your district

tween the flood of 1897 and the prior great floods—those of 1882 and 83?—A. The flood of 1897 was everywhere higher than previous ods.

Q. You might take some of the leading points along the river and ve us, if you can, the difference in high-water stages.—A. It was out 3.25 feet higher at Vicksburg, about 1.2 feet higher at Natchez, out 1.33 feet higher at Red River, about 3 feet at Plaquemine, and out 2 feet at New Orleans.

Q. How much at Donaldsonville?—A. About 2.2 feet.

Q. How much at Warrenton?—A. At Warrenton, about 3 feet.

Q. And how below?—A. Only three-tenths of a foot difference at rt Jackson.

Q. Above New Orleans, then, it probably ran from 2 to 3 feet?—A. es, sir.

Q. The excess of 1897 over prior floods?—A. Yes, sir; from 2 to 3 et, about.

Q. And then below, it was from 2 feet down to a few tenths of a ot?—A. Yes, sir.

Q. It is a fact, is it not, that the volume of water, as well as the gauge, Cairo, in 1882 and 1883, was fully as great as in 1897?—A. No, sir; have never thought that it was as great. The extreme height of the uge was as great or a little higher, but I do not believe that the volume water that passed Cairo in those years was greater than what passed 1897, at least not at stages of the river that would endanger the vee line. I base that on merely my own investigation of it. The exeme height at Cairo was maintained a very much longer time in 1897 an it was in 1882.

Q. But the stages were higher?—A. The extreme stage was a little gher; but in 1897 we had a stage above 48 feet for forty-one days, as ainst only fifteen days in 1882.

Q. To what do you attribute the excessive height of the flood of 1897, your district, over that of the prior great floods?—A. I attribute it, imarily, to levee construction in the districts above.

Mr. BERRY. If other causes contributed, please state what they were, ıptain.

The WITNESS. I think the greater volume of water passed at high ıges had a great deal to do with it, as also the long duration of these gh stages. And, thirdly, I would attribute it to the fact that the vees did not break to the extent they did in 1882.

Q. Did any crevasses occur in your district; and if so, where?—A.) important crevasses. I had one at Glasscock, which is within 4 les of the end of the levee system, in the Lower Tensas district, d also one near Baton Rouge at a place called Conrad, but this evasse was closed within six days from the time the levee broke.

Q. The Glasscock crevasse was not closed until after the flood?— No, sir.

Q. How wide was the gap?—A. About 1,400 feet wide. It was not ought wise to undertake to close it, because it was doing practically damage, being within 4 miles of the end of the levee system. The ıd was under water on the back of the levee as well as on the front the time it broke.

Q. Most of the levees of your district have been constructed by local thority, have they not?—A. The greater part of the yardage was ilt by the local authorities, but the United States has now built, in ıole or in part, somewhat more than half the length of the line.

Q. What is the proportion, if you can give it, of the levee yardage in

your district which was constructed by local authority and by Federal authority?—A. It is impossible to get accurate information as to the total yardage put into the levee line from the beginning; but from the best records available the total yardage constructed by local authorities since 1865 is 42,763,000 cubic yards, the United States have constructed 24,490,000 cubic yards. These totals do not however represent existing yardage, as a considerable portion of the work done has from time to time been destroyed by the river. Of the total length of the existing levee line the United States have built, in whole or in part, about 67 per cent.

Q. You mean new levees, built by the Government?—A. Not necessarily new levees, but about 67 per cent of the length of the line, has been built in whole or in part, by the United States.

Q. When were those levees that you speak of completed? Prior to to the flood of 1897 or since?—A. There has been but little work done as yet since the flood of 1897.

Q. The gauge of levee height that you had adopted prior to the flood of 1897 is now regarded as insufficient, is it not?—A. Yes, sir. It was regarded as insufficient before the flood of 1897, also.

Q. How much higher on an average would they require to be made now to make them safe?—A. I would say 3 feet on an average.

Q. Three feet higher than they are at present?—A. Yes, sir.

Q. What is the average height of your levees above New Orleans?—A. About 12 feet.

Q. Then you would require on an average a 15-foot levee?—A. Yes, sir.

Q. To make your levees safe and permanent?—A. Yes, sir.

Q. Do you know how much the Federal Government has expended in levee construction within your district?—A. When funds now available are exhausted the total expenditure will amount to $5,036,254.80.

Q. What is your opinion in respect to relieving the floods or overflow of the river by means of utilizing existing outlets, by additional outlets, or by the outlet system, as it is called?—A. I believe in utilizing the existing outlets, but I think it would be a mistake to create new ones. I think that, when an outlet is made, in the course of a few years the carrying capacity of the river below it and that of the outlet together will amount to only the same thing as the original carrying capacity of the river below the outlet.

Q. To-day the Atchafalaya (you were with us there to-day) carried practically all the water of the Red River and a considerable portion of the Mississippi water as well, did it not?—A. Yes, sir; all of the Red River water and a great deal of the Mississippi water.

Q. Should you say that half of the volume of the Atchafalaya to-day is composed of Mississippi River water?—A. Yes, sir; I should say at least half.

Q. And the other half is the entire volume of the Red River?—A. Yes, sir.

Q. Do you think there is reasonably any immediate danger that the Mississippi River will break into the Atchafalaya?—A. I do not.

Q. Beyond the amount that flows into it to-day from the Mississippi?—A. Well, of course, the volume that the Atchafalaya carries is variable. It often carries a vast deal more of the Mississippi water than it is carrying to-day.

Q. Of the Mississippi water?—A. Yes, sir; a great deal more than it is carrying to-day.

Q. It is a very valuable safeguard, then, as an outlet?—A. Yes, sir; is valuble as it stands to-day.
Q. And it would be wholly unsafe to close it up as an outlet for the ississippi River, would it not?—A. I think at present it would.
Q. Or even with a levee system increased 3 feet, as you suggest?—. Yes, sir.
Q. You would regard it as unsafe and unwise to close the Atchafaya River?—A. Yes, sir; I should. As to the danger of its enlarg-g, we have constructed some sills and dams that you perhaps noticed -day.
Q. Yes; you have two mattress sills there?—A. Yes, sir.
Q. Has the effect of those been beneficial?—A. Yes, sir; although e Atchafalaya has enlarged somewhat since they were constructed.
Q. Is Bayou Plaquemine being utilized as an outlet in part?—A. o, sir.
Q. Not now?—A. No, sir.
Q. It was before the construction of the locks were entered upon?—. I think it was closed a long time before that.
Major HARROD. It was closed during the war.
Q. Have you charge of the construction of the lock there?—A. No, r.
Q. But you know about it?—A. Yes, sir; in a general way.
Q. Does not that contemplate utilizing the Plaquemine as an outlet?—. No, sir.
Q. Not at all?—A. No, sir.
Q. In any shape?—A. No, sir.
Q. Well, Bayou Lafourche is an outlet, is it not?—A. Yes, sir.
Q. And it would not do to close that up, would it?—A. I think the lume that the Lafourche carries is insignificant. I do not think it ould do to close it up, because it would be injurious to navigation.
Q. What do you think of constructing outlets at Bayou Manchac, by ay of the Amite River, into Lake Maurepas, or from Bonnet Carré er to Lake Pontchartrain?—A. I think it would be very inadvisable.
Q. And injudicious?—A. Yes, sir.
Q. How about Lake Borgne—Cowden's plan?—A. I think the same to that.
Q. His plan is to make an outlet into Lake Borgne, as I remem-r?—A. Yes, sir.
Q. You regard that as not being feasible?—A. It is feasible, but I ink it would be very injudicious.
Q. What would you suggest for the improvement of the navigation the river and for the protection of the country against floods?—A. think that altogether the most important question is that of bank otection. All the other work that we do is temporary and can only such until the banks are held.
Q. Something was said in the testimony of Colonel Stickney about ur constructing spur dikes at New Orleans?—A. Yes, sir; we have number of spur dikes at New Orleans.
Q. Is bank protection the object of those?—A. Yes, sir; to prevent e caving of the bank and the destruction of property thereby.
Q. Where are these dikes?—A. We have some at Southport, which just above New Orleans.
Q. Near Carrollton?—A. In the same bend with Carrollton.
Q. Is it on the west side?—A. On the east side, on the left bank, near arrollton. Then we have two more at Amesville and a number of

others at Gouldsboro. Those are on the right bank, and there is quite a long series in the Third district of New Orleans on the left bank.

Q. How are they constructed?—A. They consist of a mattress about 400 feet long and 150 feet wide and 2½ feet thick. On that mattress are placed cribs. The cribs are of the same construction as the mattress, only they are 6 feet high instead of being 2½ feet high. A number of cribs are placed one upon another until the tops of them come to a slope of about one on three, starting from low-water mark down to the bed of the river.

Q. You pile mattress upon mattress, then, from the bed of the river up?—A. From the bed of the river up.

Q. You do not use any piling?—A. No piling on that work.

Q. You place one crib on top of another?—A. Yes, sir.

Q. How do you find that kind of a spur dike operates in protecting the bank from erosion?—A. On the whole, in New Orleans, they have worked very well. They prop up the bank locally.

Q. Is it the result of those spur dikes that silt gathers in behind them on the lower side?—A. We have never yet detected that there is any deposit between the spurs.

Q. Neither above nor below?—A. Neither above nor below.

Q. Well, silt goes into the mattress, does it not, and helps to anchor it?—A. Yes, sir.

Q. And builds up a barrier?—A. Yes.

Q. But do those dikes in their operations stop the erosion of the bank?—A. So far we can not say that they have actually stopped it, but they have checked it enough so that we have not yet had any serious caving in any bend where we have put them.

Q. You regard them, then, as still in an experimental state?—A. Yes, sir; but a very promising experiment at New Orleans and quite so above. But the conditions are somewhat different up the river; so the experiment is not so encouraging above New Orleans. It has not been thoroughly tested up the river until this season. We are now putting in a series of dikes at Giles Bend, just above Natchez.

Q. Does your district extend above Natchez?—A. Yes, sir; my district extends to near Vicksburg.

Q. And you have put these spurs in that little bend?—A. Yes, sir.

Q. You have not got that completed yet?—A. This season's work is very nearly completed.

Q. Have you carried it far enough so you can ascertain whether any beneficial effects have been derived from it?—A. No, sir; we can't tell that as yet.

Q. Please state to the committee such recommendations and suggestions as you have to make with respect to the improvement of the navigation of the river and the checking of floods—preventing the land from being overflowed.—A. I have little to recommend beyond continuing what we have been doing; proceeding with levee construction, with bank protection, and, as a temporary device, with the dredging work.

The whole question appears to me to be one of dollars and cents; no one disputes that the work can be done, the question being merely whether it can be done within practical limits of cost. In this connection I would recommend that appropriations be made early in the season, and that authority be given to make contracts in advance of appropriations, as is the usual custom under the continuing-contract system. A contrary policy sometimes forces upon us an increase in the cost of the work amounting to as much as 30 per cent.

I am also of the opinion that a slight change in organization would

bring about a speedier solution of the difficult problems connected with the improvement of the river. I believe that to secure uniformity, continuity, and consistency in the work there should be one member of the commission without any other duties than planning, directing, and supervising the work on the river. He should serve for a long term and be content to make this his life work; the district officers should serve under his orders and disburse the funds; and their tour of duty should also be long—at least six years—as the work now suffers from the frequency with which it changes hands. On the other hand, much younger men than those now on duty would serve the purpose, and since the position would be a particularly undesirable one, both professionally and personally, lieutenants serving on the Lower Mississippi, under the orders of a senior officer, should be allowed captains' pay, as it is most desirable, to secure the best results, that they should be willing and anxious to retain their positions for at least six years.

There is urgent need for concentrating the best thought and talent available upon the question of bank protection; millions of dollars can be saved by a speedy solution of this fundamental problem.

There is great need for more system in the construction and maintenance of levees. At present there are in my district six distinct forces that work independently toward building and maintaining the levee line: The individual planter, the railroad, the parish, the levee board, the State, and the United States. There is no coherent system of cooperation between these forces, and it is only thanks to the exceeding amiability of the people concerned that great and injurious confusion has been avoided. I believe that the best results can only be obtained by legislation which will put the levee system on the same basis as the District of Columbia—the local authorities depositing their taxes in the United States Treasury and the United States taking charge of the levee line, expending upon the line of each district the amount deposited by that district plus an equal amount of Federal funds.

Such a system would incidentally secure a great advantage to the country, in that the improvement of the levee line would, by reason of the thicker population and larger taxable values, proceed more rapidly at the lower end of the Mississippi Valley than above. In this way all of the yearly addition to the safety of the valley would be a net addition; whereas, if the improvement is allowed to go on more rapidly above than below, as is now sometimes the case, there is no net addition to the safety of the valley, for the additional safety given above is far more than counteracted by the additional danger below, due to the increased flood heights caused by the improvements above.

Q. Do you dredge in your reach of the river?—A. A little; yes, sir.

Q. At low-water stages?—A. Yes, sir.

Q. Where?—A. At a place called Fords, the worst crossing I have.

Q. Where is that?—A. Just below Natchez. And the channel we went through to-day, lower Old River, in former days used to go dry entirely at low water. We now maintain a channel of 5½ feet there.

Q. What has been the effect of the construction of the levees upon the navigability of the river at low stages of water?—A. I do not think it has had any effect at all.

Q. What has been the effect of the construction of levees upon the bed of the river, as to lowering or raising it?—A. I am inclined to think that the weight of evidence is that it has slightly lowered the bed.

Q. There has been no increase in the height of the bed of the river?—A. No, sir; no net increase.

Examined by Mr. BERRY:

Q. If I understood you correctly, in the beginning of your testimony you said much more water passed down during the flood in 1897 than in 1882?—A. Yes, sir; at the dangerous stages of the river.

Q. I will ask you if the destruction of the levees below was not in part attributable to the effect of the long-continued high water?—A. In 1882?

Q. In 1897.—A. I think not.

Q. You do not think that that caused the levees to give way—the fact that it remained high for a longer time than usual?—A. No, sir. The levees that gave way above my district gave way very quickly, and gave way by reason of the extreme height of the flood. Down in my district the two that broke were from entirely local causes.

Q. From defects in the levee and not by the beating of the waves against the levee?—A. Yes, sir.

Examined by Mr. GALLINGER:

Q. In view of the possibility of the Federal Government assuming control or guardianship of the levee system, I would like to ask you what your opinion is as to the probable cost of maintenance of the levees after they shall have been constructed, giving it, if you can, in percentage of the original cost.—A. I think 5 per cent quite too high for that purpose; 2½ per cent would be ample, in my judgment.

Q. What facts or theories do you base that estimate upon?—A. I do not believe that every levee would have to be renewed once in twenty years; while it is true that the levees we build on caving banks probably will have to be renewed that often, I do not think that those on the other banks will. It is true that the bends are working down, and that therefore, in the course of time, the parts of the banks that are now making will some day become caving banks; but the process of the downward movement of the bends is a very slow one.

My district contains 584 of the 1,342 miles of levee on the river below Cairo, and during the past five years the loss from all causes has only amounted to 3,666,000 cubic yards. As this is less than 7½ per cent of the estimated contents of the line, the annual loss has been rather less than 1½ per cent. With correctly located levees I think the loss should not exceed 2 per cent for the whole river.

Q. But while some levees will last longer than twenty years, will not others last a shorter time, and will there not be a partial destruction?—A. No, sir; I do not think any levee ought to last less than twenty years, except where a mistake has been made and the levee has not been located properly. Of course we do make such mistakes occasionally, but they should be rare in the future.

Q. Of course you do not lose sight of the fact that there will be crevasses, and, because of the change of the current, a necessity for rebuilding portions of the levee?—A. I think there ought not to be crevasses, sir, when we get the system in working order. They certainly ought to be very few, and not enough to affect the question of maintenance appreciably; and long before the twenty years' life of new levees has expired I believe the bank protection problem will have been solved and the levee sites will have become permanent.

Colonel GILLESPIE. I would like to say that the commission did make some examination in 1893 to ascertain exactly what this loss was for a period of ten years. Of course that takes the levees on the lines as they were adopted, and the reconstruction on practically the same lines. And from 1882 to 1893, a period of ten years, the loss in actual

ength of miles was 445; or, as it was estimated by the commission, 40 ›er cent. It was on that basis, I think, that the life of a levee was estinated at twenty years.

Q. That would be 4 per cent a year?

Colonel GILLESPIE. About 4 per cent a year. This includes the loss n the various districts. It was found that the greatest loss was in the 'egion where we would naturally expect it—in the Lower Yazoo, the Jpper Tensas, and the Middle Tensas. The Middle Tensas gave us he greatest percentage. The percentage in Lake Borgne was 22, the owest percentage. Now how that table was gotten and the conditions inder which the percentage was given can be more accurately told by Major Harrod, but all my consideration of the life of a levee has been :ontrolled by that examination, which was made about two years prior :o my becoming a member of the commission, and it was given at 40 ›er cent for ten years.

Mr. BERRY. The loss on a complete system of levees would not be ıearly so great as that between the years 1882 and 1892, would it?

Colonel GILLESPIE. No.

Mr. BERRY. Nothing like it?

Colonel GILLESPIE. No.

Mr. GALLINGER. The loss for the ten years was 40 per cent of the ɜntire system?

Colonel GILLESPIE. Yes.

Mr. GALLINGER. But there was a very considerable amount expended, was there not, on what was not lost, which would have to be added to the cost of maintenance—money which was expended by the Government in strengthening the existing parts?

Colonel GILLESPIE. Yes.

The WITNESS. That would not come in under the head of maintelance. That is improvement.

Colonel GILLESPIE. All I wanted to emphasize was that the statenent that the life of a levee was twenty years was the result of investi;ations and observations made by the commission itself for a period of en years.

Mr. BERRY. Including the high-water periods of 1882, 1883, and 1884?

Colonel GILLESPIE. Yes, sir; I think so; and if there is anything xceptional about the table, I do not know it.

Major HARROD. That estimate was made on the losses of the oldime locations, when the States were very much pushed for money and ad to make their locations very near the bank. A very material nprovement has already been made, and I have no doubt but what hat will be reduced fully one-half or to the figure which I mentioned ı my testimony when a complete and well-located system is in existnce. All the new levees are farther from the bank, and, in obedience ɔ a resolution of the commission, are designed to last at least twenty ears. The State authorities have cooperated in that improvement of ›cation.

Colonel GILLESPIE. But your variation is very much smaller than it ; in the upper districts. In moving them back to provide for this wenty years' life, your moving back has been very much less; you ave followed more generally the general lines of the river than the eople in the upper districts.

Major HARROD. Because the caving is very much less rapid and the ame retirement from the bank is not necessary.

Examined by Mr. NELSON:

Q. You have had a great deal of experience in levee construction,

and are familiar with the prices paid for the work. Will you please state to the committee your experience in reference to the cost of levee construction?

The WITNESS. The most economical work that I have done since I have been here was two years ago. Then we let contracts to the amount of about 5,000,000 yards for 10.3 cents per yard on the average. The price varied from 7.45 to 25 cents, but the average was 10.3.

Q. What was it before that?—A. In 1893 it was 21.2 cents.

Q. What was the price when you first came here?—A. For 1894 it was 14.96 cents.

Q. And it has been going down right along?—A. The figure I have given (10.3 cents) was the bottom mark. Then it went up again.

Q. What is it now?—A. About 14 cents. But I think the rise is mainly due to lack of management. Last year we were obliged to provide for doing our work the last five months of the year, during the most unfavorable season; we were compelled, inasmuch as the funds did not become available earlier, to throw a whole year's work upon the market, to be done in five months; you can easily see what must be the effect of forcing upon the market more work than all the contractors upon the river could possibly do. We cornered our own market and put contractors in a position to demand any price they chose. The remedy for the future is to make the funds available earlier in the season and permit us to make contracts in advance of the appropriations, as is usually done under the continuing contract system.

Q. If you had plenty of money and could let the work in the proper time and for the proper season, what could the work be done for in your opinion?—A. I am confident that the estimate of 15 cents for the work, that the commission has suggested, is ample.

Q. It would not exceed that?—A. No, sir.

Q. More likely to be lower?—A. Yes, sir; 12 cents or even lower, if we have the opportunity to do the work on business principles.

J. A. OCKERSON, sworn, testified as follows:

Examined by Mr. NELSON:

Q. What is your profession?—A. I am a civil engineer.

Q. How long have you been engaged in that business?—A. About twenty-five years.

Q. By whom are you now employed?—A. By the United States Government, under the Mississippi River Commission.

Q. How long have you been engaged in that employment?—A. Ever since 1879, with the exception of two years.

Q. And what work have you been doing in that period?—A. I have had charge of the general surveys of the river from which these maps that you see in the atlas have been made, and of all the investigations of the physical features of the river, such as the raising of the bed, the discharge, the caving of the banks, and matters of that sort.

Q. Now, I wish you would take up the subject your own way, and give us what information you can in regard to the matter, and what conclusions you have arrived at with reference to the subjects we have been investigating.—A. The matter of improving the Mississippi River involves two distinct problems: One, the regulation and control of the floods; and the other, the improvement of low water navigation.

There are two prominent methods of controlling the floods: First, by means of levees of sufficient height and size to carry the flood vol-

ume safely to the Gulf; second, by means of reservoirs to hold back the surplus water. I believe that it is not too much to say that nearly all engineers who are familiar with the physical characteristics of the stream feel confident that the floods can be controlled by means of levees. At the present time we have about 1,293 miles of levee. One hundred and fifteen miles of levee lies along the St. Francis front, extending down from Point Pleasant, Mo., to Pecan Point, about 35 miles above Memphis, and from Kents to Walnut Bend Landing, 6 miles, a total of 121 miles, leaving about 100 miles yet to build.

The Yazoo front levee, 311 miles long, begins at the head of Ham Lake, about 15 miles below Memphis and reaching to a point about 15 miles above Vicksburg, near the head of Eagle Lake.

The White River front levee, 64 miles long, begins at Helena and extends down to the lower end of Laconia Circle, about 10 miles above the mouth of the White River.

The Tensas front levee, 303 miles long, begins near the Arkansas River and thence runs to the Mississippi River at Lucca Landing, 12 miles above Arkansas City, cutting off the overflow at the head of the Tensas Basin.

From Lucca Landing the levee runs along near the river to near Bougere, about 32 miles above the mouth of Red River.

The Atchafalaya front levee, 207 miles long, extends from the junction of the Red and Atchafalaya rivers to about 1 mile below Fort Jackson.

The Pontchartrain and Lake Borgne front levee, 207 miles long, extends from the hills at Baton Rouge to Fort St. Philip.

The length of river from Cairo to the lower limit of the levee line is about 1,033 miles.

The area subject to overflow in the St. Francis Basin is about 6,706 square miles. In the White River Basin, about 956 square miles. In the Yazoo Basin, about 6,648 square miles. In the Tensas Basin, 5,370 square miles. In the Atchafalaya Basin, about 8,109 square miles. In the Ponchartrain Basin, about 2,001 square miles—a grand total of 29,790 square miles, or 19,065,600 acres.

The protection from floods of a tract of this magnitude is necessarily a gigantic enterprise, involving a very large outlay.

Estimating the levee system as it stands to-day as averaging 15 feet high and costing, at 15 cents per cubic yard, about $23,320 per mile, and we have the value of existing levees as about $30,152,760.

This amount by no means represents the sum of money that has been expended in perfecting the line.

A large percentage of it has been built and rebuilt on account of caving banks and crevasses.

Even as they now stand the levees are neither high enough nor strong enough to confine such floods as 1882 and 1897, and about 100 miles of levee is still lacking to close the Lower St. Francis Basin.

To bring the whole system up to the standard required to control future floods will cost about $20,000,000. After this is done comes the question of maintenance. Estimated at 5 per cent of the total cost, this would require an annual outlay of about $2,507,638. This amounts to about 13 cents per acre for the entire overflow area.

It will be seen that very large expenditures are essential to the successful completion and maintenance of a levee system, but the great interests involved amply justify them.

From an engineering point of view, the levees should be developed

from the upper end of the alluvial basin downstream, but the magnitude of the interests at the lower end demands that they should be protected as the levee system is developed.

The great flood of 1897 tested the levees and soon exposed the weak points. In the St. Francis front there were twenty-three breaks from 50 to 3,000 feet long and aggregating 13,255 feet long.

In the Yazoo front there were six breaks, aggregating 9,260 feet long.

In the White River front there were fourteen breaks, aggregating 16,525 feet in length.

In the Tensas front there were four breaks, aggregating 5,230 feet long.

Nearly all of the breaks were caused by the water flowing over the tops of the levees.

From the Red River down to the forts, a distance of 280 miles, the flood was carried between two parallel lines of levee without a break that was not closed before the flood subsided. The volume of this flood at Carrollton, at a maximum stage of 18.7 feet, was 1,350,000 cubic feet per second.

The Atchafalaya carried a maximum of 406,000 cubic feet per second.

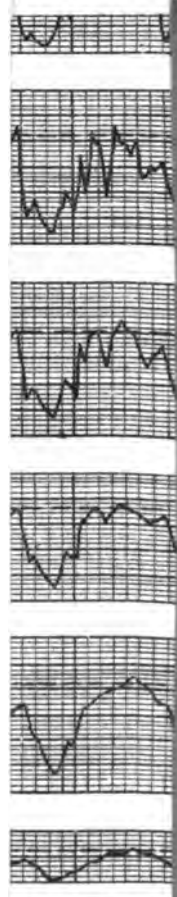
The total extent of the breaks amounted to about 8.8 miles, or a little over a half of 1 per cent of the total length of levee line.

From a point about 100 miles below Cairo to the Gulf the stage reached in 1897 was greater than any previous record. As far as volume of water is concerned, however, the flood of 1882 was much greater than that of 1897. The flood of 1882 stood above the danger line at Cairo, or 42 feet on the gauge, for a period of seventy-two days. The flood of 1897 stood above the danger line for a period of fifty-four days. During the flood of 1897 the tributaries below Cairo were all rather low.

Table showing relative heights of floods of 1882 and 1897.

	1882.	1897.
Cairo	51.9	51.6−0.3
Belmont	45.1	45.1 0.0
New Madrid	40.9	40.3−0.6
Cottonwood Point	37.5	39.3+1.8
Fulton	36.7	37.5+0.8
Memphis	35.2	37.7+2.5
Mhoons	39.8	41.6+2.8
Helena	47.2	51.8+4.6
Sunflower	41.7	47.3+5.6
White River	48.4	52.4+4.0
Arkansas City	47.1	51.9+4.8
Greenville	41.7	46.8+5.1
Lake Providence	38.3	44.4+6.1
Vicksburg	48.8	52.4+3.6
St. Joseph	44.9	47.9+3.0
Natchez	47.8	49.8+2.0
Red River	48.5	50.2+1.7
Bayou Sara	39.3	43.8+4.5
Baton Rouge	36.0	40.7+4.7
Plaquemine	31.3	36.3+5.0
College Point	23.2	28.0+4.8
Carrollton	15.0	19.0+4.0

I have here a hydrograph, which may be of interest. It shows a continuous record of the stage of the Missouri River at Hermann, Mo., the Upper Mississippi at Hannibal, Mo., the Middle Mississippi at St. Louis, Mo., the Ohio at Paducah, Ky., the Lower Mississippi at Cairo, Ill., Helena, Ark., Lake Providence, La., Red River Landing, La., and Carrollton, La., for a period of twenty-six years including the flood of 1897.



hydrograph was marked "Exhibit CC" and follows here:
backwater from the Mississippi extended up the White and sas Rivers a distance of about 115 miles during the flood of 1897.

Examined by Mr. BERRY:

To what cause do you attribute the additional height of water the river, at the points you have named?—A. I attribute the onal height to the construction of levees, confining the flood to er limits.

Do you think that the return water from the St. Francis Basin, h the mouth of the St. Francis River, contributed to make the higher below the mouth of the river at Helena and the other immediately following down the river?—A. Below the mouth of . Francis?

Yes, sir.—A. I have no doubt it did.

In your opinion was the water higher at Helena after the return of the St. Francis joined the main body of the flood, than it would been if the entire St. Francis Basin had been leveed?—A. I am ble to say. I think it would have been not far from the same t.

You can not give a definite opinion in regard to that?—A. No, sir; not.

But you think it would be about the same?—A. Or perhaps a higher with the basin leveed. In my judgment; yes, sir.

e next subject I consider is that of outlets.

e reduction of flood volume through artificial outlets has quite a ber of advocates.

outlet, in order to be efficacious, must be so situated as to carry ll water above a bankful stage. In order to be of any use it must the upper end of the basin and not at the lower; otherwise, the will spread over the basin and the damage will be done before the t is reached.

ere is no practicable outlet above the mouth of the Red River. is 765 miles from the upper end of the basin. This means that t two-thirds of the delta would be overflowed before the first ticable outlet could be reached.

low the Red River are bayous Manchac, Placquemine, and La-he. The first two have been closed for many years. The Manchac ite insignificant in dimensions now, and can hardly be told from rdinary plantation ditch.

e Atchafalaya and Lafourche are open, and as a consequence they ire levees on both banks to control the flood water. For these other reasons engineers are opposed to outlets, as they can at best only local relief, and it is preferable to put all of the available funds on the main river. Then, too, comes the question of reduc- of channel capacity due to diverting a part of the flood volume. generally conceded that the ultimate effect of a permanent outlet reduce the capacity of the stream. Hence, the supposed benefit mes in time a positive detriment.

RAISING OF BED.

ere is a popular impression that levees are instrumental in raising ed of the river. In order to ascertain just what had happened een the high-water banks from 1882–83 to 1894–1896, a resurvey made covering the river from the mouth of the Arkansas River to ollton, a distance of about 550 miles.

It may be well to state that in these surveys the elevation of the be of the river above a given datum plane and below fixed bench mark established along the river, is determined.

Therefore, knowing the elevation of the bed of the river at the tim of the first survey, which was about the time that active levee buildin began, and determining it again after a lapse of twelve to fourtee years, gives us a definite means of comparison.

The problem is really not as simple as it seems to be at first glanc Changes in the bed of the stream are going on continually, and investigations were confined to a single locality, it might show either raising or lowering of the bed. It is only by a large number of obse vations, covering a great length of the river, the conditions as to stag and relations as to length of time after a flood being the same in bo surveys, that we can reach conclusions of any value. Even after all these precautions, the results only show the general tendency, but the do show this very definitely.

Changes in elevation of the bed occur with every change of th stage. The first effect of a rising stage is to scour out the bed an increase the channel capacity. This continues up to nearly the cre of the flood.

By this time the load has become great, and the velocity of th declining stage slackens. This induces deposit, and the capacity the channel deteriorates rapidly.

The bed, for the time being, is raised, at least on the bars or crossing As the river approaches the low-water stage, the water is materiall obstructed by the raised bars, which act as dams. For a time no det nite channel exists, and then when a sufficiently low stage is reache the bars begin to cut out at the most vulnerable points. Changes this character are continually going on.

As before stated, it is essential to have a large number of observa tions extending over a long stretch of river, in order to obtain th desired information.

There were about 140,000 elevations of the river bed determined i the comparative surveys spoken of. The results of these comparison as given in my report on the subject, are as follows:

(1) The channel capacity in 1894 was greater than in 1881–82, du largely to changes above the low-water line.

(2) The crests of the shoal bars in 1894 were, on the whole, lower tha in 1881–82. This refers to the actual elevation of the bottom, and no to the depth of water on the bars.

(3) The maximum depth of pools was generally less in 1894 than i 1881–82.

(4) The thalweg depths were, on the whole, less in 1894 than i 1881–82. That is to say, a little more than one-half of the length of th river considered, shows a raising of the bed, and a little less than ha of the length the bed was lower. A large percentage of the raised be was in the pools.

(5) The high-water bars lying between medium and bankful stage wer cut down.

(6) The general tendency is toward a channel more uniform in dept and of greater capacity.

There is other definite evidence going to show that the bed has n risen as a whole. It is to be found in the low-water readings in th leveed section. These show clearly that with the same depth of wat in the channel as formerly we have gauge readings much lower durin the extraordinary low waters of 1894, 1895, 1896. To put it in anoth

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' the high stage is due to the raising of the bed, then the low should also show increased readings. It is, perhaps, well to hat all gauges are referred to fixed bench marks, so that no ›s in the elevation of the gauge itself can occur without detec- In other words, the zeros of the gauges are maintained at the levation from year to year.

RESERVOIRS.

servoir system, in order to eliminate the disastrous effects of ods and confine the water within the river banks, must reduce lume at Cairo to about 1,000,000 cubic feet per second, or, in vords, it must provide for the storage of a maximum of about quare miles of water about 10 feet deep. Provision must also be 'or emptying the reservoir after the flood has passed, in order to e it for the succeeding flood.

furthermore important that the reservoir be near the upper end delta, in order to afford the largest measure of protection prac- . The ideal reservoir should be located not very far from the 'aters, and to add to its efficiency as large a volume as practicable be carried off by the stream itself.

asting about for a site for a reservoir, it is only natural to look large basins of the Missouri and Upper Mississippi. A brief ıation of these basins and a comparison of their flood periods ıose of the Lower Mississippi River is sufficient to demonstrate servoirs in that region would not better the flood conditions of rer river. The flood periods are rarely, if ever, coincident with ›ds of the Lower Mississippi.

ıess here produced a blue print, which is attached hereto, being t D D, as supplementary of the testimony just given.

ıuing the same line of investigation in the Ohio Valley, it is soon ined that this basin dominates the flood conditions of the Lower sippi. The Ohio River, combined with the Tennessee, Cumber- ınd other tributaries, invariably produce the disastrous floods we are striving to control.

›, then, is where the reservoir should be located, if the physical ons of the country will admit. Examinations made some thirty ıgo seemed to indicate that no practicable reservoir sites of suffi- apacity could be found in that basin. This examination, how- as more in the nature of a reconnaissance, and the deductions are ›re not based on the accurate data desirable for the definite solu- such an important problem. The opinion, however, is generally ıat conclusive evidence was gathered showing that reservoirs in ısin are impracticable.

›pting this conclusion as correct, there is only one other locality worthy of consideration. This is the St. Francis Basin, extend- ›m Commerce, Mo., to the mouth of the St. Francis River. It an area of about 6,700 square miles. It is about 175 miles long raight line, and averages about 30 miles wide. It has a slope of 120 feet. In order to utilize it for a reservoir, it would be neces- › divide it up into a series of reservoirs by means of several cross ›r levees, all provided with suitable gates to regulate the outflow. ıpossible to say just how this could be done without first making ›y of the topography of the basin. We know, in a general way, is filled up with sloughs, swamps, and ridges, and that only 15 per cent of it is cleared land.

The upper end of this reservoir must be wide enough to take in a maximum of about 600.000 cubic feet per second. This would mean a stream about 5 miles wide, 5 feet deep, and flowing at the rate of about 5 feet per second.

Just what effect this diversion of the top of the flood would have on the channel capacity below the intake is somewhat problematical. Judging from our usual experience with crevasses and outlets, we should expect the channel to deteriorate. But inasmuch as the same volume now escapes into the swamps and always has done so, it does not seem probable that the channel conditions would materially change. The capacity of the basin, when provided with the necessary dams, seems to be sufficient to hold the surplus from the greatest known flood until the crest has passed the lower end of the basin in the main stream. It is not safe to go beyond this general statement. It is impracticable to formulate even a general plan for the utilization of this basin as a reservoir without further careful investigation. And even the question of possibility must remain unanswered until the results of such investigation are available.

As bearing on the question of cost, the value of the lands is important. There are in the basin about 300,000 acres of cleared land, 1,750,000 acres of timber and swamp, 352,000 acres of land owned by State, etc., and 4,300 acres of United States lands. The estimated value of these lands is about $8,600,000.

If, on further investigation, it should be found feasible to utilize the St. Francis Basin as a reservoir, the practical results would be: First, that the further extension of the levee system below the basin would be unnecessary, and the levee work would be practically transferred to the dams of that basin. Second, the bad navigation of the river at low water below the basin would be eliminated by ample outflow from the reservoirs. The bank erosion below the basin would be very materially lessened by decreasing the range of oscillation in stage. This would add very materially to the stability of the present levee line. Fourth, the lands now outside the levees, in the small basins between the river and the bluffs, would be largely relieved from the overflow which threatens destruction from the perfected levee system. These lands cover an area of about 2,000 square miles. If the protection was found to be complete then the cultivated land along the St. Francis front might be thrown outside of the reservoir.

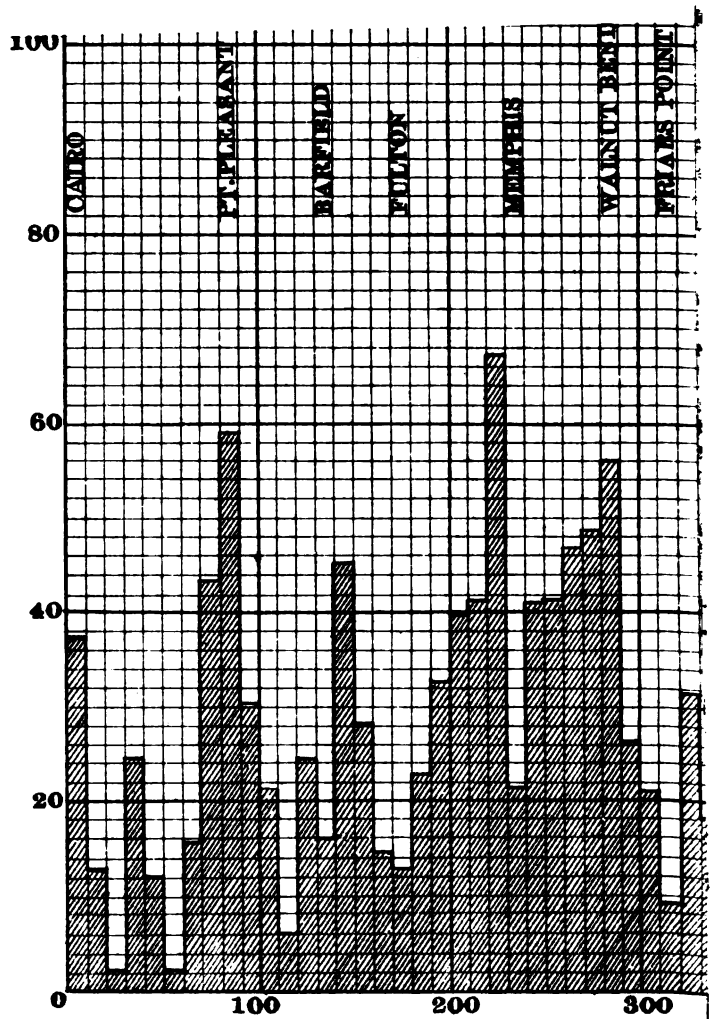
As to the question of the reasonable cost of a reservoir system we must consider the benefits to accrue as outlined above, and we also have a measure in the estimated cost of a perfected levee system. If the same or better results can be obtained by means of reservoirs at a cost not exceeding the cost of a levee system such cost may be fairly considered reasonable.

If a reservoir system were practicable the measure of protection would be far greater than any levee system could possibly be.

PERMANENT IMPROVEMENT OF LOW-WATER NAVIGATION.

The necessity for the improvement of low-water navigation is practically confined to that portion of the river between Cairo and the mouth of Red River, except, of course, through the passes.

The bad navigation lies in the wide, straight reaches of the river, while the bends usually afford safe navigation. The erosion of the banks is a great factor in the deterioration of the channel and an active agent in the destruction of towns as well as levees.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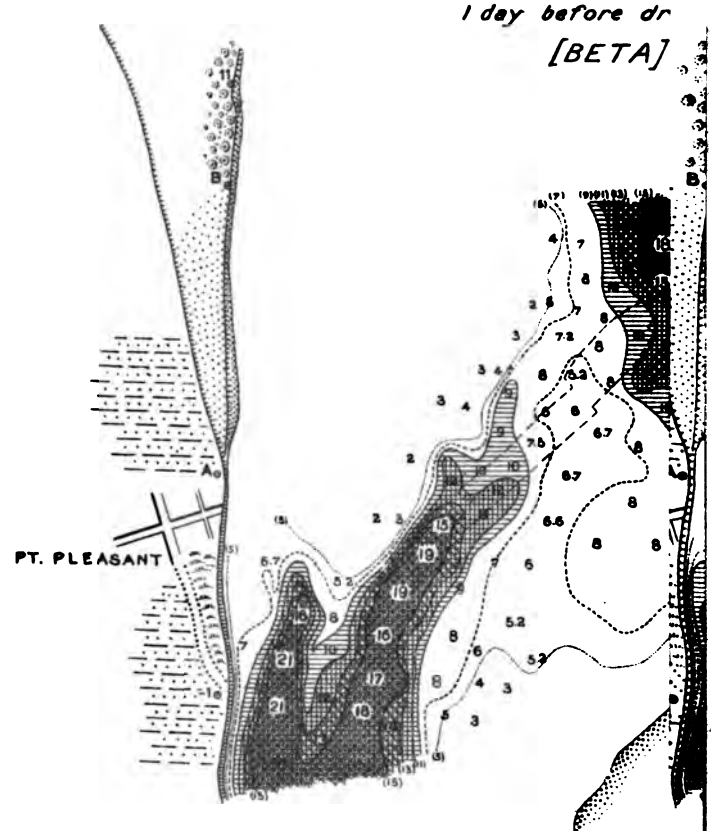


In 1892 surveys were made to determine the amount of bank erosion during an interval of about ten years. The results are given in my report to the commission in 1892.

As a part of his testimony the witness here produced the following plate, marked "Exhibit EE."

This report shows that the average annual amount of erosion is about 3½ acres in area and 66 feet deep for each mile of river. This represents a total between Cairo and Donaldsonville of 10 square miles 86 feet deep annually. The distance between the points named is 885 miles, and the total length of caving banks is 921 miles—that is to say, the caving is going on at one bank or the other for the whole distance, and the caving banks are slightly overlapping. This immense amount of material finds lodgment in the channel, and is a potent factor in the building of bars, which obstruct navigation.

If caving were stopped the prime cause of bad navigation would be eliminated. It is more than likely that one bank or the other between Cairo and Red River, 750 miles, would require revetment. This, together with closure of side chutes, is the only thing that can be done in the way of the permanent improvement of low-water navigation.

The cost of a work of such great magnitude would necessarily be very great. The standard revetment, such as has been found to answer the requirements, costs about $30 per running foot, or $158,400 per mile, a total of $118,800,000.

CUT-OFFS.

There are some advocates of the cut-off theory for bettering the condition of the stream.

The effect of a cut-off must of course be to increase the slope, and consequently the velocity. This means extraordinary activity in bank erosion for a long distance above and below the cut-off, resulting in a short time in a restoration of the former length. This does immense damage to the levees and private property. It is more desirable to increase the curvature and flatten the slope. Could this be carried to a point where the energy of the flowing water and the stability of the banks would be in equilibrium, a large amount of the caving would cease.

TEMPORARY IMPROVEMENT OF NAVIGATION.

Among the great number of plans proposed for temporary improvement of the low-water navigation of the river, the most promising is by means of hydraulic dredges of large capacity—from 600 to 2,000 cubic yards per hour. Such dredges have been in operation for three seasons. In 1895 we had one dredge; in 1896, two dredges; and in 1897, four dredges. We will have six dredges ready for work during the low-water season of 1898.

The work done by these dredges has demonstrated that a channel can be opened through the bars and that the channel generally maintains itself throughout the low-water season after it is opened.

There are some plates here that show very plainly the condition of the channel before the dredging was done, the condition of the channel immediately after it was done, and the condition of the channel a month or more after it was done.

One of these plates is appended, marked "Exhibit FF." It shows in figure 1 a depth of only 7 feet between the two pools A and B one day before dredging began, and less than 6 feet along the line that was dredged. Two days after dredging, shown in figure 2, the least depth

in the cut is 12 feet. Seventeen days after dredging figure 3 shows a least depth in the cut of 11.8 feet.

Q. What does that indicate?—A. It indicates that there is no doubt about our being able to open through the sand bars a channel of sufficient magnitude to satisfy the demands of navigation.

Mr. GALLINGER. How about their filling up?

The WITNESS. They will remain open until the high-water season. They will fill up at the first high water, and the dredging operation has probably to be repeated at the next low-water season.

The matter of the mechanical appliances for handling great quantities of material at small cost has been solved. Much remains for us to learn by experience still as to just how the dredge cuts should be made so as to secure the best results in the least time. Temporary relief of some kind is absolutely essential, and dredging or some other suitable means for deepening the low-water channel should be carried on as an adjunct to the permanent improvement of the river, in order that the great value of the stream as a commercial highway may be fully utilized.

The completion of permanent works of improvement would require such a great length of time, that before it could be of any use to commerce there would be little or none of the present traffic left to be benefited by it, and it seems to me temporary work should be going on in connection with the so-called permanent improvements all the way through.

There is one other thing of which I wish to speak, and that is in regard to the flood of 1897. The flood of 1897 does not give us a measure of what might have happened with a levee system which had remained intact throughout. The heights which I have quoted, greater at one place and less at another, are due to crevasses which occurred at different times and at different places along the river, and that, of course, leaves the stage that would have actually been reached by a completely confined flood still somewhat problematical.

Mr. NELSON. Owing to the great number of crevasses that occurred in the flood of 1897, the gauge measurements did not afford a correct standard at all points?

A. No, sir.

Examined by Mr. BERRY:

Q. How did you ascertain the value of the lands within the St. Francis Basin?—A. There were two estimates made. One estimate was made by the levee board and one estimate was made during the flood of 1892. Just how reliable either of them is I do not know.

Q. Do you know the price per acre?—A. No; I do not.

Q. That includes all the land in Missouri and Arkansas?—A. Yes, sir; all of the lands subject to overflow by the Mississippi River.

Q. Estimated at something over $8,600,000?—A. Yes, sir.

Q. Lying between what points? How far back did you go?—A. To the limit of the overflow basin; not including the highlands, of course, that are essentially above overflow now.

Q. You did not include any land that might be overflowed by the construction of a reservoir?—A. No, sir.

Q. But only those that were overflowed under the conditions that existed?—A. That is all.

Examined by Mr. GALLINGER:

Q. You seem to indicate, Mr. Ockerson, that it is possible to construct a very large reservoir in the St. Francis Basin. Did I under-

stand you correctly on that point?—A. I think I stated that even the question of possibility would have to be deferred until a more careful investigation could be made.

Q. Then you are not absolutely sure that engineering science can successfully construct a reservoir in that basin?—A. No, sir. Our present knowledge of the topography of the basin does not justify a definite conclusion as to the possibility of utilizing it as a reservoir.

Q. Now as to the matter of cost. You suggested that if that were done it would eliminate the necessity for completing the levee system. Did I understand you correctly on that point?—A. I think I stated it would obviate the necessity of extending the levee system beyond what we have now.

Q. You estimate it will cost $20,000,000 to complete the levee system. How much of that amount would be saved by the construction of this reservoir, admitting that its construction is a possibility?—A. If it were possible, I think it would save all of it beyond the work we have in hand at the present time.

Q. And the cost of the real estate in the basin is estimated at eight millions——

Mr. BERRY. That which is subject to overflow?

Mr. GALLINGER. Yes; the land which the witness says would be utilized for the purpose of such a reservoir.

Mr. BERRY. He did not say it would not overflow a great deal more land in there if a reservoir was constructed.

Q. Are you prepared to give even an approximate guess as to the cost of constructing a reservoir, supposing it could be done?—A. No, sir; I would not want to venture a guess.

Q. Would it, in your judgment, be a much larger amount than it would take to complete the levee system?—A. I think probably it would be a larger amount.

Q. Possibly two or three times as much?—A. I would not care to go beyond the statement I have just made. I think it would be larger.

Mr. NELSON. Would there not be great danger of such a basin filling up with silt from the inflow?

A. In the course of time it might. A number of years ago a project was on foot to raise the level of that particular basin by cross levees, catching all the silt that might come in there, and the investigation resolved itself into this, I think, that it would take about four hundred years to secure a deposit of 1 foot over that basin. So I do not think the question of the deposit of silt would be a material matter to consider.

Examined by Mr. HARROD:

Q. You say that to get sufficient relief from such a reservoir the reservoir would have to take in about 600,000 cubic feet per second?—A. Yes, sir.

Q. And that, taking in that volume of water from the river would not seriously affect navigation, because about that much escapes already into the St. Francis Basin?—A. I think so.

Q. Now, when you say it would not affect navigation, do you mean along the front of the St. Francis Basin or all the way down the river?—A. I mean along the front of the basin only.

Q. What do you think would be the effect on the river from the St. Francis Basin down if the flood discharge were permanently reduced from 1,600,000 cubic feet to 1,000,000? Would not the channel accommodate itself to that 1,000,000 and ultimately the flood heights be substantially the same?—A. I do not think so. If a uniform volume

of flow could be maintained throughout the year at about a medium stage the channel conditions would doubtless be better than they now are, when the oscillations in stage have a wide range. If we can approximate this uniform condition by adding appreciably to the low-water flow from a supply stored in reservoirs, the channel capacity should, if anything, be enlarged. At the worst, the river would carry between its natural banks as much water as it did before the floods were measurably controlled by levees. There are no evidences of marked deterioration of channel capacity under such conditions, nor of marked improvement, with the entire flood volume confined between levees. The bed of a silt-bearing stream flowing through an alluvial region is molded by the conditions which recur most frequently. It is the result of average conditions rather than overbank flood conditions, which prevail only about 7 per cent of the time.

STEAMSHIP WHITNEY (MORGAN LINE),
Below New Orleans, La., February 9, 1898.

Mr. M. J. SANDERS. Mr. Chairman and gentlemen of the committee, I understand that what you wish to-day is more particularly expert testimony as to the relative values of the passes of the river, and as to whether the present pass is or is not sufficient for our present commerce, and if not, what we desire to suggest to you as necessary for our commerce. I therefore will not occupy your time with any statistics to prove the value and the absolute necessity of deep water to accommodate the most economical and the largest tonnage of the world. I take it for granted that such reference as that needs be only incidental; that the committee are probably fully convinced of such necessities. I desire, however, with your permission, for the purpose of clearly defining the position of the executive committee of the general conference, to make a statement here which shall put us on record before yourselves and publicly upon a matter which we think of great importance to the coast, which we are advocating, and which we think is rendered necessary by certain comments and innuendoes that have been conveyed to us. [Reading.]

The executive committee of the general conference of exchanges of New Orleans, whose petitions to Congress have been indorsed by the business exchanges of the leading cities of thirteen States of the Union, desired again to state clearly and positively that it has no connection in any way whatsoever with any contractors or parties who may be seeking to obtain a contract from the Government for the opening of Southwest Pass. That it does not advocate or presume to suggest to Congress the means whereby the Southwest Pass may be opened up to commerce, but confines its efforts strictly and entirely to urging upon the Government the imperative necessity of immediately opening up the best possible pass from the river to the Gulf, in order to meet the necessities of commerce. The committee is anxious to have it understood clearly and unmistakably that it has not and will not have the slightest connection with any contract to benefit any particular parties and that its sole object is to secure the benefit to the whole country which will accrue from an improved channel to the Gulf.

I have taken the opportunity of reading that, Mr. Chairman, because I find it is desirable that we should be on record publicly before you upon that point.

Now, I will take up just a few moments of your time, if you will per-

mit me, in trying to illustrate how very keen the competition for deep water to-day is, and what tremendous value a few inches, even, in depth of water has to a commercial community. And I will illustrate it by referring to a controversy which has recently taken place and has caused a tremendous amount of public feeling in Boston, New York, Philadelphia, and Baltimore, on the question of the Plimsoll mark, which is a mark cut in upon the side of British vessels and marks the depth to which those vessels may be submerged when deeply loaded. That mark is inserted there by the British Board of Trade, and there is a tremendous penalty imposed upon a British captain or ship owner who loads his vessel so as to submerge those marks beyond their definite legal rights. The British Board of Trade ordains that there shall be a winter North Atlantic mark, and also a winter mark engraved upon the sides of the vessels. The difference between these two marks is 6 inches.

By some arrangement the port of Baltimore has been permitted to load its vessels down to the winter mark; whereas the ports of Boston, New York, and Philadelphia have been allowed to load their vessels only to the winter North Atlantic mark. That is to say, vessels loading at Baltimore had an advantage over vessels loading at the more Northern ports of just 6 inches in their draft. Now, 6 inches appears to be a trifling consideration in the depth of water in a channel; but this has been of such tremendous importance to commercial communities that three Northern ports resorted to every possible means they knew of to have that restriction removed, and have finally taken the matter to the British Government. They agitated the matter through the various exchanges in England, through the underwriters, and every business body they could, and brought all the influence they could to bear so that ships might be loaded from the three Northern ports to this additional depth of 6 inches. I merely mention that to show how much 6 inches of draft evidently is. That additional 6 inches means, in the modern large vessels, 300 tons of freight additional in each vessel.

The revolution of the last few years in shipbuilding still continues. There is every evidence that we are by no means at the extreme of modern tonnage. There is every evidence to support the idea that within the next two or three years vessels will be built as long as 900 feet, a beam of 90 feet, and a draft of between 35 and 40 feet. It is impossible to build vessels (so far as engineers know at present) at a reasonable cost, to be 900 feet long, without making them considerably deeper. And the business men of Liverpool, who in my experience never have been known to be ahead of the times very much, and certainly never have been known to spend a dollar without the positive certainty of getting two or three back for it, have been so convinced of this revolution of shipping and the extent to which it is likely to continue, that they have recently decided to spend $17,500,000 for no other purpose in the world than to make wider dock entrances and deeper sills to their already most magnificent system of docks. I merely mention these matters, gentlemen, to show that it is a positive certainty that in the near future, so far as any business man can calculate, we shall see ships, not of 500 feet length (such as we have at present trading to the port of New Orleans), but that if we can accommodate them we shall see ships 700, 800, or 900 feet length wishing (at all events) to trade to this port. This I mention simply to give you an idea of what we feel sure we shall need in the next two or three years, in the way of navigation accommodations for these vessels.

When I tell you (as you doubtless know) that a vessel carrying 25,000 or 30,000 bales of cotton, as they do to-day out of this port, can be navigated with almost the same expense for fuel and for men as a vessel that ten years ago carried 5,000 bales of cotton, it is self-evident that the economy of the large vessel is such an enormous force that it is bound to bring this revolution to its extremes. America to-day, fortunately it can be said, stands preeminent in the matter of economical tonnage. Congress has been wise in liberally appropriating money for the benefit of its harbors. To-day the American people are reaping that benefit to an enormous extent—a hundredfold more than the money that has been spent, by the decrease in the cost of ocean transportation for their goods from this country to Europe—to the competing markets of the world. And, gentlemen, our point is simply this: That the money we wish you to expend is in the nature of the best possible business investment that can be made for this country. It is simply like a manufacturer who, seeing his old machinery has become more or less obsolete, at once puts in new machinery. If he has not the money at hand to buy the machinery, he borrows that money; because he knows that without the most modern and most economical machinery he can not possibly continue in the race of competition. And that is so, most positively, in the markets of the world with which America has to compete—Australia, Argentina, India. And that is why we are so earnestly anxious that we shall be provided with the best possible channel, so that we shall be able to use the most economical machinery that the world can provide for the benefit of the producers in the interior of this country.

Examined by Mr. VEST:

Q. Is there a severe competition as to these ocean rates of transportation, and do they fluctuate?—A. I do not know, sir, as a business man, of anything in the world that is as competitive as ocean rates of freight. I know the conditions in New Orleans, and I know how they are in other parts of the country. We compete strictly at all times. I have seen ocean rates of freight fluctuate to the extent of 300 per cent in three months. As business men, you know that if we had such a fluctuation in the price of wheat, cotton, or corn, speculation would be impossible. A fluctuation of 10, 15, or 20 per cent in the price of wheat affects all the markets of the world. And yet ocean freights are so competitive that they frequently fluctuate as much as 300 per cent in the course of three months, showing the strictest and keenest competition of any business that I know of in the world.

Q. What is the largest number of bales of cotton that has gone out from the port of New Orleans, through the passes, in one ship?—A. There was a cargo of some 24,000 bales sent out, and the vessel carrying that also had a quantity of corn and other products on her. Her total capacity in cotton was 28,000 bales. We have no trouble, sir, with vessels loaded with light cargoes, such as cotton. We can bring in the largest vessels in the world, so far as depth of water is concerned, and load them out with cotton, because such vessels will draw but 22 or 23 feet of water when they are loaded with cotton. The difficulty is when they are loaded with grain. Then they go down to their full depth, and we can not load the big modern vessels out of this port at all loaded only with grain; it is impossible.

Q. I saw a statement (I am quoting from memory and you can correct me if I am not correct) some time ago that a vessel went out from the port of New Orleans with 377,000 bushels, I think, of grain. Is that right?—A. I know the vessel to which you refer. Last summer the

steamer *American*, with a capacity of 11,400 tons dead weight, in the month of September, when grain was coming in, was loaded by the agent with all the grain he could send out, with some 4 or 5 tons of space in her hold, and loaded her then as deeply as he dared in order to safely get her to sea. He put into her 288,000 bushels of grain, on which he obtained an average of 9½ cents per bushel, giving him a net freight from New Orleans to Liverpool of $23,400. She drew 25 feet 11 inches fresh water mean draft. Fortunately a southerly wind blew when she sailed and some 2 to 3 feet of water was blown into the pass, and she got safely to sea after only some twenty-four hours' detention at the head of the pass. That vessel carried 288,000 bushels. Had there been sufficient water in this pass to get her safely to the Gulf, she could have carried 372,000 bushels, and at 2 cents per bushel less upon the cargo, she would have earned precisely the same net freight.

Q. That is, with a full cargo?—A. With a full cargo.

Q. Now, who lost that 2 cents difference?—A. Not the ship, sir.

Q. Did the producer lose it?—A. I presume the producer lost it. It was carried at a competitive rate, but the ship did not lose it.

Q. Is it a fact that vessels are loaded with a good deal less than their carrying capacity on account of the condition of the jetties?—A. We have to-day a list of forty-five vessels (probably a larger list than trades to any other port in the world—I mean of modern immense tonnage vessels) which can not load full cargoes of grain out of this port; not one of them can load full cargo of freight and get to sea.

Q. Does the fact that they can not load a full cargo increase in every instance the cost of transportation?—A. Unquestionably.

Q. And if they could carry to their full tonnage it would inure to the benefit of the owner of the grain?—A. Undoubtedly, sir; competition would force it that way.

STEAMER WHITNEY, MORGAN LINE,
Below New Orleans, February 9, 1898.

JAMES B. QUINN, sworn, testifies as follows:

Examined by Mr. NELSON:

Q. Major Quinn, are you the United States engineer in charge of the Government works below the head of the passes?—A. I am.

Q. How long have you occupied that position?—A. Since the middle of January, 1891.

Q. Are you familiar with the different passes?—A. Yes, sir. And on the present occasion I have taken some soundings.

Q. What are the principal passes?—A. The Southwest Pass, South Pass, and Pass à Loutre.

Q. The South Pass is the pass that has been improved under the Eads system, is it not?—A. Yes, sir. That is the only pass that has been improved.

Q. Will you please state as briefly as possible the character of the improvement?—A. When they first undertook to improve the pass, there was a bar existing at the head of the pass, and one also at the sea end of the pass. The method of improvement adopted was by dredging and the using of drainage dikes, spur dikes, and so on, and jetties in the deep water of the pass, toward the sea end, out to the deep water of the Gulf, contracting the pass to a certain extent, so as to promote the natural scour by the action of the water, and so scour out these obstructing bars, the idea being to secure a depth of water

throughout the pass suitable to navigation as it then existed and permit the entrance of the deepest draft vessel that would probably enter for a considerable length of time, not being over 25 feet. The portion of the pass from the head to the beginning of the jetties, which were to extend into the Gulf, was to have a channel with a navigable depth of 26 feet. The channel between the jetties, where it was necessary to have the deepest water for ships entering under all conditions of weather, was to have a greater depth. The original acts did not specify the depth which is maintained at present, but these acts were amended by subsequent legislation, so that the present channel, as required by law, is a 26-foot channel, with a width of 200 feet, having through it a central depth of 30 feet without regard to width.

Q. In what part is that?—A. That is between the jetties at the sea end of the pass, and beyond the jetties to the deep water of the Gulf.

Q. From the head of the jetties to the deep water of the Gulf, then, it was to be a channel 200 feet in width?—A. Two hundred feet in width.

Q. And 26 feet deep, with 30 feet depth in the center or thread of the channel?—A. Yes, sir; without regard to width.

Q. And as to the balance of the pass?—A. Simply a navigable depth of 26 feet; the specific width never was stated.

Q. It was to have a navigable depth of 26 feet?—A. Yes; a channel depth of 26 feet is the reading of the law; so it left the width of the channel in a vague way.

Q. That covered the pass clear up into the main river, did it?—A. Yes; into the main river.

Q. Now, take first the bar at the head of the pass. State what improvements have been made at the head of the pass and the character of them.—A. There were certain jetties and wing dams and training walls built to confine the water in such a way that the bar would partially wash out; and the channel has been maintained by their existence and the influence which they exert in the deflection of the current.

Q. Did that work include a mattress sill across the head of the Southwest Pass and a mattress sill across the head of Pass a Loutre?—A. When Mr. Eads placed the mattress sills there he found that it was necessary to direct the flow of the water through the different passes in such a way as to secure a sufficient head of water in South Pass to give him the necessary current to scour it out. It is a question, of course, whether the use of mattress sills was absolutely essential.

Q. I am not asking about that, but was that a part of the improvement made by Mr. Eads?—A. Yes, sir.

Q. He placed those two mattress sills in the channel?—A. Yes.

Q. And he also built retaining dikes extending up into the main channel of the river?—A. Exactly.

Q. On both sides of the proposed channel of the South Pass?—A. Yes.

Q. And what were the improvements made at the lower end?—A. He built jetties on both sides of the pass, the east jetty being the longer.

Q. Do you remember how long?—A. That is about 2½ miles.

Q. And about how long is the west jetty?—A. The west jetty was not quite as long. It was about two-thirds as long.

Q. Now, there was first an outer line of jetties constructed, was there not?—A. There was an outer line of jetties constructed. The bill as originally passed required that the channel be a thousand feet wide; but that was found to be wider than they could obtain by jetty work

at this particular pass, and the bill was subsequently amended so as to give a lesser width.

Q. Did he construct that outer line of jetties on both sides first?—A. I believe so. I will not speak of that positively.

Q. And then, after that, interior lines of jetties were constructed?—A. Yes.

Q. How far apart were those lines?—A. Seven hundred feet apart.

Q. Were there any works inside of those interior lines?—A. Spur dikes were run out from the interior jetties, which reduced the channel between the ends of the spur dikes to 650 feet.

Q. What is the average width of the channel from the head of the pass to the deep water, down to what you call the 30-foot curve in the Gulf?—A. Between 600 and 660 feet. It would average about 625 feet.

Q. What is the condition of the channel in that width as to navigability?—A. It has varied at times, owing to the shoaling of the channel. It has not always had this depth of 26 feet of water, there being times when that depth has failed.

Q. Now, tell us what has been the character or stage of the water at low stages of the river. What has been the average low-water navigable depth?—A. We have had the 26-foot depth, as required by law, at low stages of the river in the pass itself. There have been very few times when that has failed.

Q. You mean down in the jetties?—A. No; I mean at low water the 26-foot depth has generally been maintained in the pass itself. Between the jetties the width has sometimes failed and a 30-foot depth has sometimes disappeared.

Q. What proportion of the time has a 30-foot depth failed at low water in the jetties, as near as you can tell?—A. Mr. Donovan, I think, could give you that better than I can.

Q. Is Mr. Donovan here?—A. Yes, sir.

Q. What has been the character of the channel at the head of the pass, where the retaining dikes were built?—A. That has been very good. We have always had deep water there, with the exception of a little bar out in the river. There has generally, I think almost invariably, been a deep entrance of sufficient width at the head of the pass to permit vessels to enter with safety.

Q. At what depth?—A. At 30 feet.

Q. It has been navigable at low water, at 30 feet, at the head of the pass?—A. Yes. Twenty-six feet only is required, but I think there has been a depth of 30 feet invariably at the head of the pass.

Q. You mean up in the river there; up above, where the pass is landlocked?—A. No; in between the jetties there has been almost invariably the full required depth of 26 feet, and more.

Q. At the head?—A. Yes; right at the head, between the contraction works, the training dikes, and so on.

Q. And there is that depth there now?—A. There is that depth there now; more than that.

Q. How is it in the body of the pass, between that and the head of the jetties?—A. There is over a 26-foot depth existing now. There is no place, I think, that has but 26 feet.

Q. In the jetties to-day there were three soundings (at this stage of water) that were less than 30 feet, were there not?—A. Yes. I have those points platted right here [referring to a chart] but I have not the means of locating them in the precise position that they occupy in the jetties. We placed them along the middle of the jetties. It is not a great distance, you see, from a 30-foot channel to a 26-foot channel, and

as long as the 30-foot channel is maintained without regard to width it would be an easy matter to get a lesser sounding outside of it. So that our soundings, which are not exactly located or platted, would hardly be an indication of the exact condition of affairs there so far as the legal channel is concerned.

Q. I am not asking for the legal channel. I am asking you for the actual channel.—A. Well, there might be a sufficient channel there of 30 feet that I do not know of existing, and our soundings may have been outside of that channel.

Q. I am not asking you what they might have been nor in regard to the legal channel. I am asking you what your soundings to-day indicated.—A. Our soundings varied from 4½ to 4¾.

Q. In some points?—A. In some points, yes; just inside the jetty.

Q. You have been here since 1891. Tell me in brief what has been the low-water navigability of that channel or the low-water stage each season during the low-water period.—A. During the low-water period, when the river is down and we have simply a tidal flow in there, the navigability of that channel has been equal to that that was required.

Q. I am not asking you that; I am asking you in feet.—A. Well, in feet—that is the required depth.

Q. What has been the low-water depth of that channel during low stages of water?—A. We have had the 26 feet, and, if we reduce that by the amount of tide, we can say that we have had 24½ feet at the lowest stages.

Q. In the low-water stage?—A. Yes. There may have been times when it reached 24, under conditions of wind or something of that kind, but, simply on account of the tidal influence, I do not think it has ever been below 24.

Q. About how long a time during each season of low water has the stage been down to 24 or 24½ feet—about how many days, weeks, or months?—A. I can not give you that exactly.

Q. When I refer to this low-water channel I am referring to a navigable channel from the head of the pass into the Gulf, and that means the lowest stages of water at the lowest points in the channel.—A. I do not know as I get your idea exactly. Now, you want the depth of water that is in the pass during low water of the river?

Q. The navigable depth.—A. A vessel drawing 24 feet could not go through a channel that was only 24 feet deep. Now that brings up the question of what is a navigable depth of 26 feet in a channel. That is a legal question that I can not determine. A vessel drawing 23 feet ought, perhaps, to navigate a channel of 24 feet, but, as a general thing, we have never had less at the low stage of the river than 24 feet.

Q. Twenty-four feet, then, has been your low-water stage?—A. Yes.

Q. What has been the average duration of that 24-foot stage during your low-water periods, for instance, each year? How many days in 1897 and how many days in other years?—A. From December 27, 1885, to March 29, 1887, there was a deficiency of three days when 26 feet did not exist. I should say that during those three days of deficiency, we had fully 24 feet, probably more. From January 12, 1891, to April 14, 1891, there were three days. From March 20, 1893, to July 21, 1893, there were thirty-two days.

Q. That is, in the jetties?—A. No; this is in South Pass, above the jetties. That is what you ask me. From April 22, 1894, to July 30, 1894, thirty-nine days' deficiency. From March 12, 1896, to June 28, 1896, there were five days' deficiency. I have given you now the total deficiencies to date in South Pass.

Q. What I aimed to get at, and to get at in the briefest way pos-

sible——A. I know, but I have not that data with me and can not tell you exactly, for I do not know without reference to the records. I think that Mr. Donovan, who made these surveys and examinations, can give you exactly what the depth of water was at the periods you want to cover. I can not do it without the data.

Mr. DONOVAN. I can not do it from memory.

Q. These gentlemen of New Orleans claim that during certain portions of the year vessels drawing over 23 feet of water can not come up or go down. I want to know whether that is so or not, and for how long a period that condition lasts.—A. The low-water stage of the river is not the time when you have the greatest trouble; it is when the river begins to fall and sand waves form in the river. It is the shoaling up of the river that causes this trouble; it is not at the low-water stage of the river; it is during the intermediate stage. Here is a chart that shows the condition of the river when there was a deficiency in Grand Bayou reach. It began on May 25, 1897, and lasted to July 18, 1897. Although there was a deficiency in this channel, the least depth in this channel, when reduced, was 24.3. We would have to add to that 1.4 feet, so the actual navigable depth would be 25.7.

Q. At what seasons?—A. That was May 25, 1897. That was the high-water season.

Q. What I want to find out as briefly as possible is what is the navigable channel in the pass at its lowest stages of navigability?—A. As I have said, during low river we seldom, if ever, have deficiencies. We have a deficiency there [referring to a chart] from December to March, but that was during high-water season. From January 12 to April, that is a high-water season. From March to July 21, high-water season—deficiency.

Q. Now, look here, Major Quinn——A. I will get hold of it after a while. I want to show that there has been no deficiency in the South Pass during low-water season.

Q. I am not asking you to show anything; I want you to give facts.—A. There was 26 feet of water in South Pass during low-water season.

Q. I am not asking you to show any particular theory, but just to give me facts.—A. Well, that is a fact. That is on record. I think I can swear to that without any doubt at all that during the high-water seasons we have had more trouble in South Pass than during low-water seasons.

Q. Trouble on what account?—A. Trouble with vessels running aground in shoal water.

Q. What was the width of your channel then?—A. We have had only 23 feet in the channel at times.

Q. Well, then, why can't you tell me, when I ask you what the lowest depth is, what it is?—A. Well, we have had as low as 23 feet in the hannel, but I can not state the time.

Q. For what length of time has that stage continued—a 23-foot navigable channel?—A. I could not state that precisely without referring to the record.

Q. Can you not approximate it?—A. No, I would not attempt to.

Q. Was it as much as a week in a year?—A. No, I could not say that with any accuracy.

Q. Now, Major Quinn, if we were to come here strangers to-day, and ask you what is the navigable depth of this pass, from the head of the pass out into the deep water of the Gulf, at its lowest stages of navigability, what would you say?—A. I should say there was a depth of 26 feet throughout the pass at a low stage of the river.

Q. Well, I mean at its lowest stages of navigability.—A. You mean

when the river is the shoalest, do you not? The river is the shoalest in the highest water.

Q. Well, you can take it at any stage you please. I am referring to the navigable stage.—A. Now the navigable stage—we have had only 23 feet of water I think at times in navigable stage. I think that is the least depth of water. I think it has not been less than 23 feet. I do not recollect any case where it was less than 20 feet deep at any time.

Q. Twenty-three feet has been the lowest?—A. I think so.

Q. Has that been for only a few instances or has there been any continuance of it?—A. That has only lasted for a few days, three or four days, probably.

Q. How many such days did you have in 1897, where you only had 23 feet of navigable water?—A. I did not say that we had only 23 feet in 1897. I said their have been times when we only had 23 feet, but I can not locate the date. I would not be positive, but I do not think that that 23 feet lasted for more than three or four days; that is, in the pass itself.

Q. Well, I mean anywhere from the head of the pass to the Gulf?—A. It has never been so little as 23 feet between the jetties. We have had practically 26 feet without fail all the time between the jetties.

Q. Now, Major Quinn, I will tell you what I am aiming at, and you can help me out if you want to, and if you want to keep on quibbling, you can do that. I am trying to find out what the channel is at its worst stages, for a ship to get through the passes to the ocean. Are there times when you only have a 23-foot channel?—A. There probably have been times when we only had 23 feet of water. I can not state how long that would be. But we have had other times, a good many of them perhaps, when we only had 24 feet of water.

Q. About how many days in each year, in your opinion, have you had 23 feet of water?—A. Two or three days, I think.

Mr. GALLINGER. Mr. Chairman, I would suggest that the word "quibbling" not go into the record. I do not think the witness is quibbling.

The WITNESS: We are a little mixed up on the subject of when these deficiencies occurred. At low water we do not have the deficiencies.

Q. I am not aiming at that, Major Quinn.—A. You asked me at low water, and I have taken you exactly as you state. Now, I can not give the time when that 23 feet that I mentioned existed.

Q. About how many days in each year?—A. It has not been in each year.

Q. Well, how many years have you had it?—A. I do not imagine that that has occurred more than once or twice in the last nineteen years.

Q. In what years did it occur?—A. I can not point that out.

Q. Did it occur in 1897 or 1896?—A. I could not say without reference to the records.

Q. Now, you have stated there were several other days when you have only had a 24-foot channel?—A. Yes.

Q. Has that occurred frequently?—A. Yes; that has occurred more frequently, perhaps. We had a long failure of channel that covered forty-five days, beginning May 25, 1897 [referring to a map]. There does not seem to have been many days when we had but 24 feet actual depth of water, irrespective of tide or anything else. At the time the soundings were made (that is the way you want to get at it), when the boat would come through she would find that much water?

Q. Yes.—A. There are very few days when we had less than 24 feet, but the precise number I can not state because I have an imperfect record with me and I can not speak from memory in regard to the matter. In a period extending over forty-five days in one year (that I have a record of here) there were only four or five days when we had 24 feet of water or less. That is one record that I can give you. And I do not suppose there have been times when we had less than that for a period of more than one, two, or three days within the whole nineteen years.

Q. Within the last three years has there been continuously a navigable channel of 26 feet depth from the head of the pass to deep water in the Gulf?—A. Now you ask me a question that involves this subject of the high water in the channel again [referring to a paper]. This gives simply the days of deficiency of the legal channel, which was 26 feet at mean high water.

Q. Now, I ask you a plain question. I will repeat it again. During the last three years have you had continuously a navigable stage of water of 26 feet depth in the South Pass, from the head of the pass to the end of the jetties, or to the deep-water navigation of the Gulf?—A. We had a deficiency in June——

Q. Can you answer that question by yes or no?—A. No; I can not. I will have to ask you to excuse me from answering it in that way. I will answer it the best I can, but I can not rely on memory to give the depths on different days. We do not seem to get together on this matter very well, and I do not seem to really understand what you want. You want to get the days that we had a depth of water that was less than 26 feet?

Q. I am not after the days. These gentlemen say that they have not had as good a channel as they ought to have had during certain seasons of navigation. Now, I am trying to find out what sort of a channel they have had; and I ask you, as the engineer officer in charge, to tell me.—A. The channel has not been straight, and, although there has been a channel through there that could be navigated, which might have over 26 feet of water, vessels have run aground in consequence of getting out of this channel. Vessels are subject to accident. That is what they are complaining of more than anything else. Now, then, you see the width of the channel is involved in that question.

Q. How wide is this channel from the head of the jetties down? I do not mean the bottom of it, but how wide is it on an average.—A. From the head of the jetties down I think the 26-foot channel will average about 150 feet. It is more than that sometimes, but that is about the average.

Q. Could this channel be deepened so as to give a navigable depth of 32 feet?—A. I think it can.

Q. In what way would you do it?—A. We would have to make extensive works at the upper end, and at the lower end to confine the water; straighten the pass in certain parts; levee the pass on each side so as to contain all the water that goes into it, and do dredging to restore depths where it is now shoal. It requires a great deal of work. I would extend the jetty system at both ends, up the rrver and down into the Gulf, levee the channel from one end to the other on both sides, dredge out the pass, and straighten it as far as possible, so as to give the required depth.

Q. And in that way you think you could maintain a channel of 32 feet depth?—A. Thirty-two feet at low water of the Gulf.

Q. At what expense could that be done, in your opinion?—A. In my opinion it would cost $3,000,000 to perfect it. We would have to pur-

chase land, build buildings for the workmen, etc. That would cost $110,000. We would have to have two dredges, which we can not build for less than $250,000. We would have to have scows and pile drivers, which would cost $50,000. We would have to have two tugs, which would cost $50,000. To that we would have to add a contingency of $46,000 (10 per cent), making $506,000 for the plant. During the first year we would have to have $500,000 to expend in dredging. The extension of the jetties at the Gulf end will cost $500,000. The levees will cost $32,000. Sheet piling dam at head of pass will cost $390,000. Contingency, $72,000. We would require for the first year that we commence work down there $2,000,000. For rectification of channel and restoration of those works which are subject to damage of material subsidence after the first year, to be held as a contingency fund for extraordinary emergencies in maintenance of work for first ten years, $1,000,000. We want that so that we can draw on it at times when it becomes necessary.

Q. For maintenance?—A. Not for maintenance exactly. One million dollars of it would be available to aid our sum for maintenance. For maintenance of such a channel we would require at least $150,000 a year in addition to this. We say $1,000,000, because we may meet with accidents and things of that kind that we can not foresee. We want that $1,000,000 as a reserve. It should be counted in as a part of the expenditure of the first two years.

Q. That is, the strict first cost would be $2,000,000, and then you estimate $1,000,000 for contingencies?—A. Yes; for a contingent fund.

Q. To cover accidents?—A. To cover accidents and extended improvements.

Q. That would make a 32-foot navigable channel how wide at the bottom?—A. Three hundred feet wide at the bottom.

Q. And how wide at the top?—A. It would be 660 feet wide at the top. It would be 32 feet in depth at mean low water of the Gulf.

Q. Now, as to Southwest Pass; could that pass be improved?—A. I think it can not be improved for any such money. I was very much discouraged with the result we got to-day from the soundings.

Q. What did we find to-day from the time we entered until we got to deep water?—A. It varied from 40 to 60 feet.

Q. From the sill?—A. Yes.

Q. What is the average width of that?—A. A quarter of a mile; at least about 1,200 feet.

Q. One thousand two hundred feet down to the bar?—A. Down to the bar.

Q. There were three or four crevasses at the head of the bar, were there not?—A. If we improve that pass, it would be necessary to apply about the same methods that we would apply in the improvement of South Pass. It would require some work at the head, in the way of training walls and jetties, and jetties at the sea end to carry the water out and the closing of all of these crevasses in between.

Q. It would not require such an extensive system of training dikes or walls at the head of the pass as South Pass does, would it?—A. No, it would not. Well, I will not say that either, because we only have 32 feet above South Pass. It probably would require as extensive a system of training dikes at the head of Southwest Pass as we have for South Pass, and I think it likely that it would require a still more extensive system of training dikes, because the pass is longer, and, in order to secure the necessary scour and head of water, we might have

to extend the works farther up the river than we do in the case of South Pass, which is a shorter pass.

Q. The present stage of water in Southwest Pass is how much? What percentage is it of the total discharge of the river?—A. Forty-five per cent of the discharge of the river goes into Southwest Pass, 7 per cent into South Pass, and the rest into Pass a Loutre.

Q. Now there was to-day something like 30 to 32 feet of navigable water at the shoalest part at the head of Southwest Pass, was there not?—A. Yes.

Q. It would require a very little effort there to get a 35-foot channel, would it not?—A. Well, it would require some work, of course.

Q. What is the length of the cross section of the bar? Now, do not misunderstand me. I may not state it as an engineer would. I mean from the deep water above in the river to the deep water in the Gulf; what is the distance across the bar in the Southwest Pass, approximately?—A. About a mile and a half.

Q. How does that compare in length with the distance that has been jettied at the South Pass?—A. We have only had about 1,500 feet of jetty at the head of South Pass.

Q. I am not speaking of the head of it now; I am speaking of the other end—the outlet.—A. The bar there is 2¼ miles in length, and we would have to have jetties at least 5 miles long. There would be 10 miles of jetties.

Q. You would require 5 miles on each side?—A. Yes, at the South west Pass.

Q. Would those jetties in themselves be more expensive to construct on that pass than they were or would have been on the other?—A. I do not think so.

Q. The character of the work would be substantially of the same kind?—A. Yes.

Q. The difference between the two, then, would be that one would require more mileage?—A. Yes, sir.

Q. More material and more work?—A. Yes.

Q. But would not that be compensated for to some extent by the fact that less work would be required between the head of the pass and the bar?—A. In the first place, I do not claim that there would be less work at the head of Southwest Pass than at South Pass.

Q. Well, now, between the head of the pass and the bar of the Southwest Pass, would there not be less work?—A. There would be if we can maintain those depths of channel, because there is plenty of water——

Q. I am speaking of the Southwest Pass. From the head of the pass to the bar at the mouth of that pass, aside from closing a few small crevasses and building levees, you would require no other improvements, would you?—A. No; no dredging of any kind.

Q. No straightening of channel?—A. No.

Q. No cutting away or anything?—A. No.

Q. So there would be that much in favor of the Southwest Pass, would there not?—A. Yes.

Q. Now, have you formed any opinion as to what it would cost to make a navigable channel in the Southwest Pass, say, 1,200 feet wide, with an average depth of 32 feet?—A. No; I have not estimated it at all. I could not estimate it.

Q. Would it cost any more than to make a channel in the South Pass of that depth?—A. I am not positive that I can gain that depth at

either pass by any system that you may undertake—35 feet. I would not guarantee or undertake it.

Q. I mean 32 feet.—A. Oh. Well, I am doubtful about our ability to secure at the mouth of Southwest Pass a depth of 32 feet at mean low water of the Gulf by any arrangement that you can make.

Q. You doubt the practicability of it?—A. Yes.

Q. But you have no doubt as to the practicability of securing that depth of channel at the South Pass?—A. I feel confident it can be secured at South Pass.

Q. What bearing has this crevasse at Pass a Loutre had on the channel in the South Pass?—A. The pass had been in worse condition since the crevasse than it ever was before.

Q. The original maximum flow of the water into the South Pass was 11 per cent of the total, was it not?—A. Of the total discharge of the river; yes, sir.

Q. And it is now 7 per cent?—A. Yes, sir.

Q. And has been about that percentage since the crevasse, has it not?—A. Yes.

Q. Are you hopeful of having that crevasse closed soon?—A. I have hopes of closing it before the next high water.

Q. And making a perfect closure?—A. Yes.

Q. Within the appropriation made?—A. Yes.

Q. If you succeed in that, you think it will help the navigability of the South Pass, do you?—A. I think it will restore the conditions that we had before.

Q. Ought Cubitts Gap to be closed to help the navigability of the river?—A. That will undoubtedly improve the navigability by giving deeper water at the head of the pass.

Q. What suggestions have you to make in addition to what you have already said with reference to the improvement of South Pass so as to make a good 32-foot channel? What would you do if the work were placed in your hands and you had sufficient money and how long would it take you to do the work?—A. It would require at least one year after the money was available to secure the necessary plant. We would then go to work and dredge, and so on, during the second year, and we would expect to gain our depth of water. We would have to do this under the complete direction of the Government. I do not think it would be advisable to let any of that work by contract; it should be carried on by day labor and under the direct control of the officer in charge of the work. That would put the control of the pass in the hands of the Government, and I think with that arrangement, carrying it out in that manner, we could make that pass secure and preserve the navigability of the pass for a number of years to come; I do not say permanently, but for fifteen years anyway.

Q. You think the Government should have possession of the pass.—A. The Government would have to have possession of the pass.

Q. And if it had possession of the pass and you had ample funds, within what time do you think you could secure a 32-foot channel?—A. I will get the 32-foot channel at the end of the second year after we get our money.

Q. Is there anything further that occurs to you, Major?—A. Nothing except this: I speak with more confidence respecting the improvement of South Pass, for the reason that I am acquainted with the conditions of South Pass. We have a record of that pass, what it does under different conditions, and I can make my calculations to agree with the conditions, and am not trespassing on terre incognita at all. If I went

nywhere else I would have to study the situation very carefully; and ; is possible to make mistakes in these things, because it does not take ıuch to upset your calculations where you have such tremendous forces o deal with.

Q. If you could secure in the Southwest Pass a navigable channel 2 feet deep at practically the same expense as you could secure a hannel of that depth in South Pass, would it not be preferable to nprove the Southwest Pass on account of its greater width?—A. Indoubtedly.

Q. And if it should turn out after examination that the work of get-ing such a channel in the Southwest Pass as I have indicated could e done practically for the same amount as in the South Pass, would ; not be preferable to make it in the Southwest Pass?—A. I think ndoubtedly so.

Examined by Mr. GALLINGER:

Q. Major Quinn, as this is a subject of the greatest possible magni-ıde, involving great interests to the commerce of the country, do you ot think it would be the part of wisdom for the Government to have thorough and complete investigation made of all these passes before xpending millions of dollars either in improving the South Pass or in ttempting to open up the Southwest Pass?—A. It would certainly be rudent to examine all the conditions connected with the problem, and articularly in the case of the Southwest Pass, because we have not ıe data at hand by which to form any definite plan for the improve-ıent of that pass or what we can do with it. We have got to make ıvestigations in regard to Southwest Pass to get that information or nowledge. We have not such data at hand.

Q. Major, how long do you think it would take the Government to ıake such a thorough and complete investigation of all these outlets ; would enable the engineers to give a reasonably definite opinion as) what would be the wise thing to do?—A. A year, I think, would be mply sufficient to secure that information.

Q. And I understand you to agree to the proposition that you think ; would be the part of wisdom for the Government to proceed in that ray rather than to indulge in what might be called a further experi-ıent?—A. Yes.

Examined by Mr. VEST:

Q. What was the depth of water in that South Pass prior to the onstruction of these jetties?—A. About 9 feet at the foot and at the ead of the pass about 4 feet.

Q. So there has been an increase by reason of the jetty work of about 5 feet?—A. Yes.

Q. You regard the jetty system as a correct one, do you not?—A. ou can secure your depth of water. The only question that we con-ider as being an improper one is the considering of this method as a ermanent and economical system. In the course of time it will reach ıch a stage that we can go no farther with it and will have to aban-on it. It will reach such a length in the course of time, from the eposit in front of the jetties, that you will not be able to go any far-ıer; you will not be able to get a sufficient head of water to maintain our channel, and you will have to give it up. And the prolongation f the pass by the natural deposit in front of it is a very serious obsta-le in the way of guaranteeing the length of this pass for any definite ıme.

Q. Then you do not consider it successful?—A. No; I think there

are other methods that you can have precisely under your control and that you can guarantee for an indefinite length of time; that you can improve to any extent that you wish in a very economical way after the thing has first been produced. In the first place, you have conditions to contend with in this river that are entirely beyond your control. You can not tell what they will be.

Until the flood of 1897 they never had 19 feet of water at New Orleans. In the early days the levees were only 4 or 5 feet high, but they have been increased in height all the time, and these conditions enormously increase the current, and so on, so the river brings down different material. When Mr. Eads took his contract, the character of the material that was carried by the river appears to have been lighter than it has been of recent years. I can only explain that on the ground that the enforced current in the river, due to the building of the levees, has caused the current to transport this sand along the bottom in greater quantities than before, and that is the material that causes all the trouble in our past—the heavier volume of sand.

Q. Major Quinn (I do not know; I have read it in the papers), have you not persistently, for some time past, advocated the building of canals?—A. I have no such project.

Q. Never had any such project?—A. When people come to me and ask me what I think is best to be done, I say that an engineer officer always selects what he is certain he can do and what he can do in the easiest manner.

Q. Well, have you never expressed the opinion that a canal would be better?—A. I have no question that a canal could be built which you could control perfectly and which you could construct in such a way that it would be absolutely permanent.

Q. Have you not publicly advocated the building of canals instead of the jetties?—A. No; I have not advocated it. I have no interest in this thing. I have only spoken of it as my opinion that that was the best solution of the problem—to get rid of the Mississippi River entirely.

Q. That is what I asked—if you do not think that that is the proper solution of the question—to build a canal instead of the jetties?—A. I still think that that is the solution of the problem.

Q. That is what I asked you—if you had not so stated?—A. And say so now. I think it is. But you asked me if I advocated it. I have not advocated anything.

Q. I asked you if you had not expressed an opinion?—A. Yes; I have expressed an opinion.

Q. As a matter of course you would advocate what you believed to be right. Have you not stated publicly in interviews, and has it not been printed in the public press, that you regard the whole jetty system as a failure?—A. Certainly I do; I consider it a failure as a permanent structure. I do not consider it a failure as a means of giving temporary relief; I think it is a success in that view.

Q. You do not look on it as permanent at all?—A. I do not look on it as permanent.

Q. We have had the system only twenty years, and have got an increase of 15 feet in the water. That is quite a step in the way to success, is it not?—A. No; I think a thing ought to stand for a hundred years without failure.

Q. Well, it has not yet disappeared?—A. It will shortly. It is disappearing pretty fast.

Mr. VEST. I hope your prophecy will not come true.

The WITNESS. Well, it will come true.

Examined by Mr. BERRY:

Q. You speak of a canal. From where and to what point could it be built?—A. It does not make much difference where you go with your canal. There is a man who is classified as a crank in New Orleans, and in 1875 he had a project for a canal from Barataria right up to the river, and that is only 50 miles in a straight line. It seems to me that that project has merit.

Q. From Barataria Bay to New Orleans?—A. Yes.

Examined by Mr. GALLINGER:

Q. It is 50 miles, then, from New Orleans to the open sea at that point?—A. Yes. Now, I have no project to advance; but suppose we adopt his project. If we brought that canal to New Orleans and connected the canal with the river by a lock of suitable dimensions to pass the shipping—you can make it 1,000 feet long if you want to, 100 feet wide, and 40 feet deep——

Mr. BERRY. Then how far would you have to go from the mouth of the canal out into the Gulf to get permanent deep water?

The WITNESS. We would have to build jetties there, not over 3 miles long.

Mr. BERRY. Out into the Gulf?

The WITNESS. Yes.

Q. Has any estimate been made by anybody as to the probable cost of such a canal?—A. This man made an estimate of $5,000,000,000; but that is absurd.

Q. Have you, as an engineer officer, or has anyone connected with the Government made an estimate of its cost?—A. No; I never thought it worth while. This system has been adopted, and I thought it was our duty to try and maintain it.

Q. Are you prepared to give an opinion as to the probable approximate cost?—A. I imagine it would cost $20,000,000. I should say that as a rough guess.

Examined by Mr. CAFFERY:

Q. Major, I understood you to say that it is only a question of time when the jetties at the mouth of the river will fail to give adequate water?—A. Yes.

Q. And that the jetty system has no permanent life?—A. No permanent life.

Q. Did I understand you correctly?—A. Yes, sir.

Q. Will you please give me the reason upon which you base that statement?—A. The continual extension of the jetties lengthens the pass. In order that you can guarantee that the material that is brought into that pass will be carried out, you have got to have a constant current. You can not maintain a constant current in that pass if you are continually lengthening the pass, because you are all the time reducing the slope or fall of the pass throughout its length.

Q. Then I understand you to mean that the jetties will carry out and deposit at the sea end of the jetties the silt of the river so as to form an embankment that will impede the velocity of the current from the jetties?—A. Yes, and eventually close the pass.

Q. Has that occurred at the end of the present jetties in South Pass?—A. There has been a building up of the bar in front of the jetties going on for the last nineteen years. We have a filling in, in places, of 20 feet right in front of the jetties. That process is going on all the time.

Q. Please state the extent of this filling up of the Gulf at the sea end

of the jetties.—A. At a point where we have 30 feet of water to-day, at the time the jetties were finished there was 40 feet of water. There has been a 10-foot fill right there, within 2,500 feet of the end of the jetties. Beyond that there has been 20 feet. The average fill over the whole area in front of the jetty has been as much as 14 feet.

Q. The average fill?—A. Yes, sir; in nineteen years. There has been carried out there in the nineteen years and deposited on this area, which is a mile and a quarter in extent, the enormous amount of 19,000,000 cubic yards. A million yards of material is carried out each year by South Pass and deposited right in front of the jetty, and within a limit of one mile from the end of the jetty. That includes all the incidental circumstances of low river and storms which have carried away a great deal of this deposit at times.

Q. And it is upon that ground only that you base the opinion that the life of a jetty is temporary and not permanent?—A. Yes; the extension of this bar renders it necessary, in order that you may maintain a channel through it, that you keep extending your jetties, and in time the extension of these jetties will go so far that the current will not be able to maintain the channel through the jetties and the thing will close up.

Examined by Mr. BERRY:

Q. Major, would there be the same deposit through the canal that you speak of as there would be through the river?—A. There would be no deposit by the canal. You can keep everything out of it.

Q. Because you can make the slope greater?—A. It is not necessary to have any slope in your canal, because you have no sediment coming into the canal. The lock at the head of the canal would keep the sediment out, with the exception of a very little that would come in with vessels.

Q. Your idea is that the sediment can be kept out of the canal entirely?—A. Yes; such a canal could be maintained just the same as any other canal.

Examined by Mr. CAFFERY:

Q. Have there been any jetties constructed on this coast, say in Texas, where the water has been devoid of silt, that goes to prove your statement?—A. Well, where we have no silt the jetties, by preventing the currents along the coast from carrying material into the channel, will guarantee a channel there for a very great length of time. Of course there will come a time when the silt that drifts along the channel will build out and begin to pour around the ends of the jetties, and then we will have bars form at the end of the jetties. But there is no jetty system, where the water passing through the jetties carries the sand or silt, that can be maintained permanently. The bar will keep building up until you reach a time when you can go no farther. But in the case of a channel that bears no silt, you can extend the jetties without danger of having the channel in between the jetties fill up. The extension in such a case might be indefinite.

Q. Now, Major, I want to ask you whether a powerful dredge boat by dredging at the end of the jetties in South Pass would not remove all that difficulty and remove the silt that you say is being deposited and checking the flow of the water through the jetties at a comparatively small cost?—A. Our modern dredges would handle a great deal of material, but the reason why the jetties were constructed was because dredging had failed to maintain the channel—any kind of a channel, 20-foot channel—across the bar. You would have to have jetties to keep

the storms from filling up your channel. You might dredge a channel across a bar, and if it is unprotected the storms, and the currents which these storms produce, will carry the material from either side into your channel and fill it up; and you can not work when you have a storm, and that is just the time when vessels want deep water.

Q. I understand you to say that there have been 19,000,000 cubic yards of silt or what not deposited at the end of the South Pass jetty in 19 years?—A. Yes.

Q. If that silt were taken away by dredges, how could storms fill up the channel at the end of the jetties when there was no silt to be carried in?—A. Maybe they would not if you could remove what accumulates—a million cubic yards a year. But that deposit is only over an area of a mile from the jetty, and it is 9,000 feet to the point where this deposit ends, and we might have nearly double that amount to deal with, because if we confined our dredging operations to this fan-shaped area it would not be long before we would have an outside area that would be just as shoal, so there might be a time when you would have 2,000,000 cubic yards and there might be times when you would not have but 500,000 cubic yards to deal with. A very low water season would not bring down much silt. But these dredging operations are not instantaneous operations; they take time; and there are conditions of the sea when you can not work your dredge and when your work would be greatly damaged by storms. It is not a certain method.

Q. Major, did I understand you to say that ships going in and coming out of this South Pass frequently stuck?—A. Because they get out of the channel. That is due to the direction in which the water issues from the jetties. The continued action of the current in the pass has a tendency to drive the material over to the west. It accumulates on the west of the pass, and tends to throw the current more into the direction of the——

Mr. BERRY. Is the sticking of these ships sometimes due to the fault of the pilots?

The WITNESS. They always say that. But there are accidental circumstances. A pilot may fail in his judgment as to how he shall steer the vessel. He carries her on, and the current strikes the vessel at an angle and sheers her off and he miscalculates the power that he has to bring that vessel up to where she should go, and of course she goes aground. It is simply an error of judgment in most cases. In view of the fact that these currents strike this vessel at an angle, with the greatest care that might be exercised in some cases the pilot is not able to judge precisely what he is able to do, and lands his vessel on the west side.

Mr. CAFFERY. Major, where do these ships mostly stick—in the pass?

The WITNESS. In the pass. We have had some vessels aground between the jetties, right near the outer end of the jetties, inside, but they have taken a sheer somehow or other and run out of the channel. There does not seem to be any real reason why they go aground there. We can not explain it exactly, but they do go aground.

Mr. BERRY. Is it not because the channel is too narrow? Is not that the main reason, instead of its being on account of the fault of the pilot?

A. Oh, I don't know. They go aground in Lake Michigan. If the channel is navigable for vessels passing each other, or passing in the center of the channel, why should the ship get out of the center of the channel if there is plenty of water in it? There is no reason that you could assign why that should occur, unless some accident occurs

to the steering device or something of that kind, and then the ship goes aground on the side of the channel. But the conditions of the channel have nothing to do with that.

Examined by Mr. CAFFERY:

Q. Suppose you had a very crooked channel, with short turns, and a long ship?—A. Then navigation is imperiled, for the reason that it is difficult to steer those very long ships, and the danger of their going aground in making turns is much greater. The channel should be as straight as a string to give perfect conditions of navigability.

Q. The channel in South Pass is crooked, is it?—A. Quite crooked.

Q. Do these ships stick where the crooks are?—A. Where they are changing from one place to another is where they generally run aground.

Q. You have stated that these jetties at the end of South Pass have to be extended farther into the Gulf?—A. Yes, sir.

Q. How much farther?—A. They should be extended within the next ten years a distance of 2,500 feet.

Q. That would be 5,000 feet of jetties?—A. Yes.

Examined by Mr. BERRY:

Q. Do I understand you to say that with $3,000,000 a channel 32 feet in depth at mean low water could be maintained from the head of the pass out into the deep water in the Gulf?—A. No; I would need $150,000 in addition to that for maintenance. I can secure such a channel with $3,000,000.

Q. Would that 32-foot channel carry a vessel drawing 30 feet of water from the head of the pass out into the deep water of the Gulf?—A. Certainly.

Mr. GALLINGER. And you want $150,000 annually to maintain it?

The WITNESS. Yes, sir; because the increased depth and the increased length of our jetties and so on will necessitate an expenditure of money of fully that much.

Examined by Mr. CAFFERY:

Q. What effect have the jetties had upon the water in the pass as to depth? Have the jetties shoaled or deepened the water in the pass?—A. There has been a shoaling of the pass in the deep-water portions. The tendency of the jetties, and the very action on which they are based, is to equalize the cross section and flow of water in the pass itself. Now you have to contract the channel at the sea end in order to secure your proper depth. When you do that you oppose a resistance. You may say if you wish that the resistance is due to the prolongation of the point of discharge, but it is simply necessary to say you oppose a resistance. That resistance is felt throughout the whole length of the pass. Now, in order to equalize its flow of water, it has a tendency to equalize its discharge all the way through the pass. That has been the experience in South Pass.

Q. How much has it shoaled in South Pass?—A. There has been an extreme shoaling in one place of 30 feet. There has been a shoaling in considerable portions of 20 feet and 10 feet.

Q. That shoaling has been simply the filling up of deep holes in the pass, has it not?—A. Yes.

Q. It has not materially affected the navigation of that pass?—No; it has not affected the navigation at all. If we made the pass of uniform depth, width, and slope, we would have an ideal pass, and the pass tries to bring about that condition.

Q. You say, then, that the pass would accommodate itself to the jetties?—A. Would accommodate itself to the jetties.

Q. You could easily secure 32 feet of water in the pass, if the pass were already of that depth?—A. Yes, if it were already of that depth.

Q. Now, it happens that Southwest Pass is much deeper than 30 feet.—A. The chances are that if you put jetties at the mouth of that pass, which will secure and maintain a depth of 32 feet, you may expect that much of that deep water in the Southwest Pass will disappear. It will shoal up until you have 32 feet and probably less in places. That has been the experience in South Pass.

Q. Would the same result happen as to the deposit of silt at the sea end of the jetties in Southwest Pass, if they were constructed, as has occurred in South Pass?—A. We would have a more rapid extension of the bar at Southwest Pass than we have at South Pass. In the first place, the discharge would be greater. It would carry more sediment, and as this sediment forms the bar, of course that would be one reason for the rapid growth of the bar. The second reason is that the currents at Southwest Pass are not of such strength as to sweep the material away from in front of the jetties, as occurs to some extent at South Pass.

Q. You say there is a difference in the currents at the ends of the jetties?—A. Yes, sir.

Q. At the end of the bar at Southwest Pass and at the end of the bar at South Pass?—A. Yes, sir. The currents which sweep the material that is brought out by the pass at South Pass and sweep it away to the westward have not sufficient strength at Southwest Pass to sweep this away in front of the pass, and it is deposited more nearly in the direction of the axis of the pass. Therefore the bar has built up much more rapidly at Southwest Pass than at South Pass—that is to say, South Pass is more favorably located for the maintenance of the entrance than Southwest Pass, irrespective of the amount of material that is brought down.

Examined by Mr. VEST:

Q. Whichever of these passes is adopted, ought the others to be closed? For instance, to close Southwest Pass and Pass a Loutre, how would that affect South Pass?—A. Well, there would be hell to pay in South Pass if you did that, I will assure you. You would have those jetties going out with a rush.

Q. You mean, then, when you say hell would be to pay, that it would not help South Pass?—A. No; it would destroy it.

Q. Why? Because it would put so much water into it?—A. It would tear all your training dikes and everything out, and you would have to go to work and reimprove the whole thing.

Q. How would it affect Southwest Pass if South Pass were closed?—A. It would not make so much difference, because South Pass has a less discharge.

Q. Do you not think that Pass a Loutre ought to be closed (without touching Southwest Pass), for instance?—A. We do not want more water to deal with than we can help. If we have sufficient water to accomplish the desired result, every ounce of water that we have outside of that is a detriment.

Q. You think, then, that you have got enough water there without closing either of these other passes?—A. Southwest Pass?

Q. At South Pass, where the works are now.—A. Yes, without closing. I do not say that we have plenty of water. That is not your idea, I guess. We would like to have more water.

Q. But your idea, as an engineer, is that you ought not to close Pass a Loutre?—A. I do not think it would be necessary to do that. We can get a sufficient head of water at South Pass by extending the works up the river—provide all the water we want for the carrying on of this object without closing any of the passes.

Examined by Mr. CAFFERY:

Q. Well, is it necessary to close that crevasse in Pass a Loutre?—A. Well, that will raise the head of water——

Q. That will raise it sufficiently without turning the whole pass down?—A. Yes. It will simply restore the conditions that existed before the crevasse.

Q. Major, I will ask your opinion as to whether the present jetties at South Pass will last much longer; and if they will, how long?—A. I think if we have good luck that we can hold them for twenty-five years longer at 32 feet.

Q. The jetties that are there?—A. Oh, the jetties that are there?

Q. Yes, sir.—A. I do not guarantee those for any length of time. I believe in ten years we will see the end of them.

Q. What could they be duplicated for?—A. I do not know what they cost originally.

Q. I did not ask you what they cost originally. What could they be duplicated for now?—A. I do not think they would cost more than $20 a running foot.

Q. Would you, in extending these jetties, use the same material as was employed by Mr. Eads in the original construction?—A. Not necessarily. I do not think that that is the acme of construction for that kind of work.

Q. What would you use?—A. I would probably use something of much more permanent character.

Q. I want to know whether the South Pass could be widened to this width without endangering the bank—causing it to cave or crevasses to form—South Pass.—A. That is, make the South Pass 32 feet wide and 600 feet at the bottom?

Q. Yes.—A. I do not think we could accomplish that with safety; no, sir: We could make it 300 feet wide with safety, and we might even then have to widen the pass slightly in order to get a slope that would stand for the banks. You see we would have to make it about 1,200 feet wide.

Q. Does not Southwest Pass offer opportunity or facility for making a channel 32 feet deep and a thousand feet wide?—A. No; I do not think we could make it a thousand feet. It is only 1,200 feet wide, and I do not think we could enlarge the channel at the bottom so as to make the deep water 1,200 feet.

Q. Well, it is a mere guess to say it is only 1,200 feet, is it not?—A. Yes.

Q. It looks like it.—A. It looks like it; yes. It is about a quarter of a mile; that is about the average. It is wider in places.

Q. Well, what width of channel could you safely make in Southwest Pass?—A. I could make it 600 feet wide.

Q. And 300 feet in South Pass?—A. Yes.

Q. Do you think a 300-foot channel in South Pass will accommodate the commerce that now goes through the river?—A. I think there is no doubt about it. If you have that depth of water, I do not think there would be any trouble. If you have a channel 300 feet wide at the bottom, I do not see why vessels can not pass in such a channel.

Q. Now I will ask you whether, in your opinion, it would be better

to improve South Pass than to undertake to improve Southwest Pass?—A. I have stated that I know what I can do in South Pass. As far as my judgment goes, I am satisfied that I can give you 32 feet of water, and I do not believe I can do it in Southwest Pass.

Mr. CATCHINGS. Why do you not believe you can do it in Southwest Pass, Major?

The WITNESS. In the first place, Southwest Pass is much longer than South Pass, and we find, with the conditions as they exist to-day, that we can not maintain all the year around a channel of 26 feet in South Pass. South Pass is 4 miles shorter than Southwest Pass. How can we expect to go on and improve a pass that is 4 miles longer and must have a current far less than South Pass, if, with the current we have in South Pass we have not been able to maintain 26 feet the whole year around? We can not get the velocity. Now it is claimed that the friction effect has something to do with this; that it is less for the large pass than for the small pass. Now, if the channels are of the same depth, that frictional resistance which affects the flow of the water, may be omitted in consideration of the flow in these passes.

Q. Would you not get all the velocity you wanted by closing up South Pass and forcing the water down through Southwest Pass?—A. You have got to increase your head of water at the head of the Southwest Pass in order to get an increased current through South Pass. You might close up South Pass, you might close up all the other passes, and the river would run over the bank somewhere else. You would have to levee the river and close it up, and if you affect the height of the river at the head of the pass, that effect is felt for a long distance up the river—goes above New Orleans a long way. It affects the whole slope of the Mississippi River for a long distance above. Now we could levee that river, perhaps, build out dikes, and everything of that kind, and get an additional head of water (by shutting off the other passes) of 18 feet. But what would be the result at New Orleans? We would have to build our levees up there 18 feet higher than they are now, and a man would have to get his freight over the levee with a balloon. If you will produce the same condition of affairs in Southwest Pass that you have at New Orleans you will have 150 feet of water.

Examined by Mr. BERRY:

Q. Major, how much would it cost to make those surveys and determine with some reasonable degree of certainty as to how much money it would cost to produce this deep water in Southwest Pass?—A. I say you can not get it.

Q. You can not get that information?—A. No; I say I am not positive that you can get 32 feet of water in Southwest Pass, and so I do not know what it would cost.

Q. You did not understand the question. How much will the surveys cost to ascertain with some reasonable degree of certainty about the matter, or such information as you can get?—A. I think we can make the surveys such as you mention for the sum of $15,000.

Q. And take about a year's time?—A. Yes, because we have to study the condition of the river under all circumstances. Did I understand you to say that that survey was simply for Southwest Pass, or all the passes?

Q. All the passes.—A. I can make the survey for Southwest Pass for $10,000.

Mr. SANDERS. If you will permit me, Mr. Chairman, I would like to ask the Major if he would give you some information about the trouble

at the Head of the Passes. We have had a number of vessels grounding constantly before they could get into South Pass from above and get to sea. I would like if the Major would give us some explanation of that in the way of overcoming the difficulty.

The WITNESS. A bar exists at the head of the pass [referring to a chart] almost in the prolongation of the axis of the pass. If the water could be extended up on the westerly side of South Pass we would have no such difficulty as that. When the vessels were grounded out in the pass they were simply out of the channel.

Mr. SANDERS. I think we understood you to say, Major, that if 32 feet of water could be obtained through Southwest Pass for about the same amount of money as through the South Pass you would prefer to have it made through the Southwest Pass?

The WITNESS. If I could obtain it for that and we could maintain it for the same money, undoubtedly it would be better to have the Southwest Pass. If I stated in regard to that exactly as you have quoted me (and I do not know whether I did or not), I should have added that the question of maintenance is involved in this thing. It will require far more to maintain Southwest Pass for the reason that the extension of the jetties will have to take place from time to time and with greater rapidity than at South Pass.

Mr. SANDERS. I understood you, also, Major (I may be wrong), that your fear as to the possibility of getting deep water through Southwest Pass is mainly based upon a comparatively longer channel and the absence of slope.

The WITNESS. Yes.

Mr. SANDERS. It was suggested to me in the course of conversation that it was not only the slope that affected the question of scouring or the question of velocity, but that it was a question of slope and volume combined.

The WITNESS. If they were of equal depths the supposition is, from the behavior of South Pass, that if you got 32 feet of water in Southwest Pass the time would not be far distant when you would have but 32 feet of water in the deep-water portion of the pass. The tendency of the pass is to fill up. It can not narrow its width, and it resorts to a deposit in the pass to restore the conditions which have been upset by building your jetties and raising a resistance. If the two channels are of the same depth, frictional resistance may be disregarded. Although the large pass would have twice the volume it would have twice the frictional resistance, so it would not cut any figure in the velocity.

Mr. SANDERS. Is it not a fact that the jetties would be twice as wide as the Southwest Pass, and would not that make a difference?

A. No; the frictional resistance would simply be twice as much in a pass twice the width of South Pass, if it was of the same depth. Suppose one pass is just double the width of the other and both have the same depth. The wetted perimeter in one is just double of the other, so, as the frictional resistance is dependent on the wetted perimeter, that question may be disregarded in considering the velocity.

Mr. SANDERS. And that is the ground of your fear for the Southwest Pass?

The WITNESS. Yes; that the pass would fill up.

Examined by Mr. CATCHINGS:

Q. You would not double the sides, but only the width. If the sides are of the same dimensions, you do not have double the perimeter. You would have to double the sides as well as the base to double the whole perimeter, would you not?—A. Say the sides were 32 feet deep,

ıat would be 64 feet for the two sides. Let me explain that to you ith a little diagram. We will say this is 45 degrees slope. This is ɔur 300-foot pass. Now, then, we will take this other pass and make it ɔuble that. These passes have the same slope. The only difference etween these two passes lies in the fact that one has double the bottom ıat the other has.

Q. Certainly, but not double the whole perimeter. I understood you ı say that the wetted perimeter would be doubled by doubling the idth of the bottom. That is not correct, is it? Doubling the width ' the bottom would not double the whole perimeter?—A. No, the sides ould be the same in each case and the only variation would be in ɔubling the bottom, so the frictional resistance would be in one ıse——

Q. It would not be double.—A. No, the unbalanced resistance would ɜ double.

Mr. A. K. MILLER. Major Quinn, has not the shoaling complained f, just above the Head of the Passes, been augmented or increased nce the crevasse took place at Pass a Loutre?

The WITNESS. We have had more difficulty in the pass since the 'evasse than we ever had before.

Mr. A. K. MILLER. Do you think that, if you could effectually close ıat crevasse, the shoaling would in some measure disappear or be overɔme?

The WITNESS. We expect that; yes.

STEAMER WHITNEY, MORGAN LINE,
Near South Pass, February 9, 1898.

J. A. OCKERSON, recalled, testified as follows:

Examined by Mr. NELSON:

Q. Were soundings taken to-day of South Pass and Southwest Pass?—.. Yes, sir.

Q. As we passed down the Southwest Pass and up the South Pass?—.. Yes, sir.

Q. Did you assist in keeping a table of those soundings?—A. I did.

Q. Is this a correct table of the soundings that were taken at the vo passes?—A. Yes, sir.

The table was marked "Exhibit GG," and follows here:

EXHIBIT GG.

SOUNDINGS MADE FOR SENATE COMMITTEE.

SOUTHWEST PASS.

[Steamer Whitney, Feb. 9, 1898.—J. A. Ockerson, recorder.]

Soundings begin opposite pilot station above the head of the pass and continue ɔwnstream through the Southwest Pass:

ıthoms.	Time.	Fathoms.	Time.
.....		6¾ (△Donovan)	8.25
.....		6¾.....	
+.....		6½.....	8.26
—.....		5.....	8.27
.....a. m.	8.22	5.....	8.28
.....	8.23	5 +.....	
.....	8.24	5 —.....	
.....		5.....	8.29

Fathoms.	Time.	Fathoms.	Time.
5½ (opposite axis of South Pass)	8.30	House on right bank passed at	8.52
5½		Stopped 3 minutes for pilot	
5¼ (opposite Head of Passes light)	8.31	Crevasse on right bank 100 ft. wide	9.10
5¼		Crevasse, left bank, 60 ft. wide	9.20
5¾		Pilot Town, and crevasse, left bank, 150 ft. wide	9.23
7¾	8.34	House on right bank	9.25
9¾ (no bottom)		Crevasse, right bank, and also on left bank	9.27
10½ (about 1 mile below Head of Passes light-house)	8.35		
Crevasse on left bank 60 ft. w	8.50		

Soundings across bar:

Fathoms.	Time.	Fathoms.	Time.
4¾	9.28	2½	
4¾		2 + (buoy)	9.47½
4½	9.30	2 +	
4½		2	9.48
4½	9.31	2	
4½ (Light-House Bayou)		2 —	9.49
4½	9.32	2 —	
4½		2 —	
4¾		2 —	9.50
5	9.33	2 —	
5	9.34	1¾	9.51
5	9.34½	1¾	
5	9.35	1¾	
5 +		11 (feet)	9.52½
5 +	9.36	10 (feet)	
5¾		10 (feet)	
5¾ (Stake Island)	9.38	10 (feet)	
5½		10 (feet)	9.52
5 +		10 (feet)	
5	9.39	10 (feet)	
5 —		9½ (feet)	9.52½
4¾	9.40	9½ (feet)	
4¼		9. (feet)	
4 +	9.41½	9½ (feet)	
4 +		9½ (feet)	9.53
3¼	9.43	9½ (feet)	
3 +		9. (feet)	
3¾		9½ (feet)	9.53½
3½	9.44	9 (feet)	
3 —		10 (feet)	
3 —		10 (feet)	
2¾	9.45½	10½ (feet)	9.54
2¾		14 (feet)	
2¾	9.46	6 fathoms (and no bottom)	
2½		8 fathoms (scant)	9.56
2½	9.47	8½ fathoms	

SOUTH PASS.

Through jetties.

[Steamer Whitney, Feb. 9, 1897.—J. A. Ockerson, recorder.]

Soundings taken in the channel coming into the jetties in the South Pass through the jetties:

Fathoms.	Time.	Fathoms.	Time.
9		4½	
8½		4¾ (bet. 1st and 2d wing dams)	
8		5¾ (2d wing dam)	
7 +		6½	
7 (scant)		7 (scant)	
5¾		6¼ (just below pilot station opp. spur dike)	
5¾		6½	
5½		6½	
(E. J. L. house)		6	
4½			

s.	Time.	Fathoms.	Time.
		5¼	
		5¼	
		5¼	
		5¼	
		5¼	
p. station coast shed)		5¼	
		5+	
		5	
		5	
		5	
		5½	
		5¼	
		East Point	

Above jetties.

[Wednesday, February 9, 1898.]

Going upstream above the jetties.

s.	Time.	Fathoms.	Time.
	1.36	4¾	
		5 (△)	2.04
ation 50)		5+	
	1.37½	(station 270)	2.05
		5¼	
tion 60)		5 (station 280)	2.06
	1.39	(Passed the steamship Cleo, of Triste, drawing 23-24½.)	
	1.40	4¾	2.07½
		4½	
ation 80)		4½	2.09
		4¾	2.10
	1.42½	5—	
		5— (station 320)	2.11
	1.43½	5½ (station 330)	
tion 100)	1.44½	5¼	
		5½	2.13
tion 110)	1.45½	5½	2.14
	1.47	5¼	2.15
tion 120)		4¾	
		4½	2.16½
ation 130)	1.48	4½ (station 370)	2.17
		4¾	
ation 140)	1.49	4¾ (station 380)	2.18
		5+ (station 390)	2.20
tion 150)	1.50½	5 (Goat Island)	
		5+	2.21
tion 160)	1.52	5¾ (station 410)	2.22
		5¾ (station 420)	2.22½
ation 170)	1.53	5¾	
	1.53½	5¼	2.25
ation 180)	1.54½	5¼ (station 440)	2.25½
		6 (station 450)	
	1.56	6¼	2.27½
tion 200)	1.57	7½	
tion 210)	1.58	5¾ (station 470)	2.29
ion 220)	1.59	7	
	1.59½	6½	2.31
	2.00	5½ (Lt.-house)	2.32
		6½	
	2.01¼	5½	2.34
		7	2.35
tion 250)	2.02½		

below head of dike, at head of Passes, left bank of South Pass.

STEAMER WHITNEY,
Above South Pass, February 9, 1898.

C. DONOVAN, sworn, testified as follows:

Examined by Mr. NELSON:

Q. Mr. Donovan, are you an engineer by profession?—A. Yes, sir.

Q. Are you employed by Major Quinn?—A. Yes, sir.

Q. Working under him?—A. Yes, sir.

Q. On the river, from the Head of the Passes down?—A. Yes, sir.

Q. How long have you been engaged in that employment?—A. Twenty-one years.

Q. How long have you been acquainted with the South Pass?—A. Twenty-one years.

Q. What has been the character of the navigable channel in South Pass during the last three years, as to depth? What have been the stages of navigability in the South Pass during the last three years?—A. During the last three years, up to January 1, 1898, there has been a navigable depth of 26 feet, except for fifty-two days.

Q. Do you mean the entire length of the Pass, from the head?—A. Yes, sir.

Q. From its head, above the Pass, down to the deep water of the Gulf?—A. Yes, sir.

Q. There has been a navigable depth of 26 feet except for fifty-two days in those three years?—A. Yes, sir; three years up to the first of the present year.

Q. About how many days has there been a deficiency during this last year?—A. Forty-seven days.

Q. And the remaining five days have occurred in the two preceding years?—A. Yes, sir. There was no deficiency in the year 1895, and five days in 1896.

Q. Five in the year 1896, no days in 1895, and forty-seven days during the year 1897?—A. Yes, sir.

Q. During three years up to the first of the present year?—A. Yes.

Q. In the forty-seven days last year you included all up to the first of the present year?—A. Yes, sir.

Q. Then the chief trouble has occurred during the year just past?—A. The greatest deficiency was in 1897, but that which has caused recent comment occurred in the present year.

Mr. GALLINGER. And most of it in the days of the present year, as I understand you?

The WITNESS. Not as regards the number of days, but the trouble was unusually serious. During the year 1898 there has been twenty-five days' deficiency.

Q. To what causes do you ascribe that?—A. I ascribe it entirely to the grounding of a steamer that was taken out during very low tide.

Q. Where did the steamer ground?—A. About midway between the head of the pass and the jetties.

Q. In the channel of the pass?—A. Yes.

Q. You ascribe it wholly to that?—A. Yes; in South Pass.

Q. From what causes did that grounding occur, as near as you can tell?—A. I can not tell anything about it.

Q. I mean, did it occur through an insufficient channel?—A. No, sir.

Q. Or through misfortune, or through a mistake of the pilot, or what?—A. I do not know, except that it did not occur through an insufficient channel.

Q. Was the vessel of a greater draft than a 26-foot channel would

warrant?—A. Yes, sir. The vessel was being taken out at extremely low tide.

Q. What is the depth of the channel in the pass at extreme low tide?—A. The average rise and fall of the tide there would be about a foot. When we have very extreme low tides the difference may be a foot and a half.

Q. When you speak of having maintained a navigable channel of 26 feet, you mean such a channel as is contemplated in the Eads contract law, do you not?—A. Yes, sir.

Q. That contract refers to what water or tide level?—A. To the average high tide during low river, during the time when the volume of the river is the least.

Q. High tide at the lowest stages of the river?—A. Yes, sir.

Q. Approximately, what is the difference between low and high tide at those stages?—A. The difference between the average high tide and the plane to which we are reduced at the present time is about 1.6 feet.

Q. I do not think you understood my question. You stated that the 26 feet under the Eads law—— A. Is at average high tide during the low stages of the river.

Q. Now, what is the difference between high tide and low tide at the low stage of the river? In other words, what is the difference between the ebb and the flow of the tide at those stages?—A. The average difference is about 10 inches.

Q. Then it would only make a channel 10 inches shoaler at low tide than at high tide?—A. Yes; but there would be occasionally an extreme low tide, where the difference would be greater.

Q. In other words, low tide and low-water stage would mean a 25-foot channel, would it not, substantially?—A. Yes, sir.

Q. Under the Eads plan, as you construe it?—A. Yes.

Q. It means practically a 25-foot channel at lowest stages of water?—A. Yes.

Q. And a 26-foot channel at high tide of low water?—A. Yes, sir.

Q. How long did that steamer stay grounded?—A. She grounded about half-past 2 on December 28. At about 8 o'clock the tug went to her and pulled her into the channel and up the channel past the place where I was told by the pilot the steamer had grounded, and pulled her up the stream. The night was dark, and he started down with her and undertook to put her through the channel with two tugs, one on either side, but he grounded her again, this time on the east side of the channel.

Q. Farther down than before?—A. Yes, but on the east side of the channel, and there remained. She was pulled off about 8 a. m. on the 13th and towed to the head of the passes. There she was anchored to await higher tides, and did not go to sea until January 5.

Q. What were the dimensions of that vessel, as nearly as you can tell?—A. I believe she was 460 feet long. Her draft was 25 feet 3 inches.

Q. With her load?—A. Yes, sir.

Examined by Mr. BERRY:

Q. Do I understand you, then, that by reason of the grounding of that vessel a bar was formed there that caused the 26-foot channel not to be maintained for a number of days?—A. Yes; the *Ramore Head*——

Q. Grounded?—A. Well, the first vessel that grounded there was the *Ramore Head*, which was the vessel that was towed off. When she grounded the second time the two tugs laid alongside of her for hours, and by working their propellers they dug the material away from her; there was no current to carry that material off and the force of the

propellers carried it just down in front of her, and there it remained and made a perfect barrier across the pass. There was no other agent to make it. I made an examination seven days afterwards and found the channel exactly the same. If the shoal had been caused by anything else there would have been some change in the channel in the next seven days. And the vessels coming down afterwards had trouble until that channel was dredged out. The contractor's dredge boat was in the city, under repairs, and four or five days after she got there the channel was deepened.

Examined by Mr. CAFFERY:

Q. Did the grounding of this vessel prevent other vessels from going up or coming down? Could vessels pass on either side of it?—A. No, sir; it prevented vessels from going up or down.

Q. Now, I want to know whether or not, generally speaking, one ship being grounded in that channel, in the Pass, will obstruct navigation.—A. Not generally; no, sir. I have seen ships aground many, many times and other vessels pass right by them.

Q. Is not the channel so narrow that if the ship lies across it, or obliquely across it, but not directly across, the grounding of it will impede or obstruct navigation?—A. Yes, sir.

Q. So that all commerce that goes out of that river or comes into that river can be obstructed by the grounding of one ship in the channel?—A. Yes; temporarily. But this is the only instance that I have known, in all the years I have been there, where the channel was so obstructed. There is usually room enough on one side or the other.

Q. Can you state about the average number of ships per annum that are grounded in the channel in the pass?—A. I do not think there were any more last year than during any other year. I think the number does not vary much from year to year. Fourteen steamers grounded last year.

Q. What was the effect of the grounding of those vessels upon the navigation in the Pass?—A. I do not think there was any special hindrance to navigation. I state in my report:

During the year I report the grounding of 14 steamers and 1 ship, as follows: One on a shoal in the entrance to South Pass at its head, 2 in Goat Island reach, 7 in Grand Bayou reach, 1 near Port Eads, 3 in the jetty channel near the sea end, and 1 beyond the ends of the jetties. But 4 of these vessels drew 25 feet, 4 drew 24½ feet, and the draft of the others varied from 17 to 23½ feet.

Mr. GALLINGER. Those latter ones must have got out of the channel, must they not?

A. Well, they do get out of the channel, of course. Now, while the *Ramore Head* was aground, the vessel following her would not undertake to pass her. She undertook to turn around in the Pass, and grounded in turning around. That was through no fault of the Pass. Just about a quarter of a mile below the Head of the Pass another steamer, drawing 22½ feet, went out of the channel—which was 36 feet deep—and grounded. The channel was 36 feet deep, and the 30-foot channel was 250 feet wide. Now, how we are going to get at the cause of those things I do not know. In this case I asked the pilot, as I usually do, what the trouble was. They tell me, "Well, she took a sheer and would not answer her port or her starboard helm."

Mr. NELSON. Was she going down or up?

The WITNESS. Down.

Q. Is it not very difficult to steer those vessels when they are loaded down nearly to the depth of the channel?—A. It depends a great deal on the way they are loaded. Vessels of the West India and Pacific

and Harrison lines are the deepest laden ships regularly coming to this port, and they very seldom have any trouble anywhere. They are specially loaded. They are loaded 2 or 3 feet by the stern. A vessel loaded in that way, if she happens to touch the bottom, is easily managed; she hangs on that as a pivot. Now, suppose they are loaded a few inches or a foot by the head; if they touch the bow the current swings them around against the bank and they are helpless. There is care taken in loading steamers of those lines, which I consider a very important item.

Q. That is when they are going downstream?—A. Yes.

Q. Does that occur when they are going upstream?—A. They seldom ground in going upstream. They generally ground in going downstream. They are usually light coming in, and they are loaded when going out.

Q. Is it not necessary, for the safe navigation of the channel, that there should be at least a foot between the keel and the bottom of the channel?—A. I should think so.

Q. So that when a channel is 26 feet all the way along, a vessel should not be carefully loaded more than 25 feet?—A. I think not.

Q. You can not steer them properly if you load them so close to the bottom, can you?—A. Well, as I am not a seafaring man, I am not supposed to know anything about that subject. But I have asked those whom I consider experts, and they claim they can take a vessel drawing 26 feet through a channel with 26 feet of water in it; usually when they come to a shallow place they just stop the vessel and let her drift over. They can not go fast over a shallow place; if they do she will settle.

Q. Have you made any surveys or examinations at the sea end of the jetties?—A. Yes, sir.

Q. What has been the effect of the jetties in the matter of depositing silt?—A. The jetties do not cause a deposit of silt.

Q. What causes the deposit if the jetties do not?—A. This deposit is simply going on all the time. The banks of the pass, as you noticed through South Pass, are only natural jetties; they are built out from year to year. Now, by those jetties which Captain Eads built across the shoal we have simply discounted nature so many years. We have not arrested the process of nature at all. That growth continued to go on there after Mr. Eads built his jetties just the same as it did before, but he has gotten ahead of nature that many years and has carried these artificial banks over the shoal out into deep water——

Q. Faster than nature would have done?—A. Faster than nature would have done it. Now, when nature catches up with us those jetties will have to be extended.

Mr. NELSON. In the same way?

The WITNESS. In the same way.

Q. If that natural process goes on, and the silt is constantly deposited, at what point in the Gulf will it stop?—A. It is going on so slowly that of course it is a question that need not interest us very much. But in the course of time, in hundreds and hundreds of years, it will be hard to tell where it will stop.

Q. Do you think that in the course of unlimited time the Mississippi River would build itself out into the Gulf through these natural jetties that you speak of?—A. I see no reason why it should not. That is the way it has been building out for hundreds of years. At one time the mouth of the river was near the city of New Orleans.

Mr. GALLINGER. Has it not been even above that point?

A. The records show that it has built itself out from even above New Orleans; yes, sir.

Mr. GALLINGER. Some claim from the Atlantic Ocean.

The WITNESS. Yes, sir.

Mr. NELSON. From the Red River, some claim.

The WITNESS. Yes, sir.

Mr. BERRY. The deposit at the Southwest Pass is greater than at the South Pass, is it not?

The WITNESS. Yes, sir.

Examined by Mr. NELSON:

Q. When did Mr. Eads have his jetties built and have the navigable channel of 26 feet?—A. The jetties were considered completed the 8th of July, 1879.

Q. Were you here then?—A. Yes, sir.

Q. And there was a navigable channel then of 26 feet?—A. Yes, sir.

Q. Through the whole pass?—A. Yes.

Q. What did the work consist of as it existed when completed? Describe it briefly.—A. The head of the pass consisted of dikes and dams built of mattress work, willows——

Q. There were first on each side two training dikes there, built up into the river, were there not?—A. The first work that was built was built on the advice of Mr. Eads's advisory board, which was composed of very eminent engineers. They recommended a dike starting from a certain point, going up into the river and intercepting 600 feet of waterway that was going into Pass a Loutre. They said, "If we drive this water down this channel, it will scour out." But that was a failure. Then Mr. Eads tried first one thing and then another in the way of dams, until he got these training walls.

Q. He put in two mattress sills, one in Pass a Loutre and one in the Southwest Pass, did he not?—A. Yes.

Q. And he connected the sill in Pass a Loutre with the training dike on that side, did he not?—A. Yes.

Q. And did he run up a training dike on the other side of the sill in the Southwest Pass?—A. The sill in the Southwest Pass connected with the jetty on the west side.

Q. Now, the end of that mattress sill in Pass a Loutre was carried away, was it not?—A. Yes, sir; some of it was carried away.

Q. In 1891?—A. Some of it was carried away before 1891, but most of it since 1891.

Q. It was carried away before that crevasse occurred that exists there now?—A. Yes; some of it was carried away before that.

Q. Do you think that the carrying away of that mattress sill tended to bring about the crevasse that occurred?—A. No, sir.

Q. In your opinion what brought that about?—A. Simply the wearing away of the bank of Pass a Loutre—the erosion of the bank.

Q. It was from natural causes?—A. Yes.

Q. Not through any human interposition?—A. No, sir; I do not think so.

Q. I heard a rumor to-day about someone having cut a channel through there?—A. Well, when the crevasse occurred I investigated it, and an oyster man told me that he discovered it when it was about 15 feet wide and about 14 feet deep, and he, with others owning oyster beds in that direction, undertook to close it, and did close it temporarily, but the next high river it began to widen and was rather more than they could contend with, and then they made it known. I did not know of any such thing until that time.

Q. About what was the length of the training dikes built by Captain Eads at the Head of the Pass on each side?—A. The first dike was about 3,000 feet in length.

Q. Does that dike still exist?—A. Some of it still exists. It is buried by the deposit which it caused and the grass of the marsh is growing right over it. Some of it is washed out.

Q. Has a bar formed inside of that dike?—A. Oh, yes. The most of the work that was done at the Head of the Pass you can see nothing of to-day; it is buried by the deposit.

Q. They do not require any replacement or rebuilding?—A. No.

Q. They are still good?—A. Yes.

Q. What was the work that you did at the jetties at the mouth?—A. It was of the same character; dikes built of mattresses.

Q. There were first outer jetties a thousand feet apart, were there not?—A. Yes, sir.

Q. And then afterwards an inner jetty?—A. Yes, sir.

Q. And then spur dikes?—A. No, sir; there was first the outer jetties; then, to narrow the channel still further, these dikes were built. And Mr. Eads found that he was required to build these dikes so frequently that he thought he would build what we call the inner jetty, which answers for a dike at every point.

Q. Was not that inner jetty supplemented by dikes inside again?—A. Yes, sir.

Q. They were built by Captain Eads?—A. Yes, sir.

Q. Now you have told us what the channel was that Captain Eads secured by that system when completed. Has that channel maintained itself ever since that time until the present time?—A. No, sir.

Q. When did it begin to deteriorate and from what causes?—A. I do not know that I can state just the date when it began to deteriorate.

Q. I do not mean just the day of the month, but the year, for instance?—A. There was no well-defined period when the channel began to deteriorate.

Q. When did you first notice any deterioration?—A. As far back as 1889. There was a period of five and one-half years, from 1883 to some time in 1888, when they did not use a dredge boat for a day; the boat was laid up all the time, and the channel maintained itself by scouring. That was when the works at the head of the pass were all in good condition, the sills across the other passes were in good condition, and we were getting about 10 per cent of the volume of the river in South Pass.

Q. Since they commenced to deteriorate, how has the channel been maintained; by improvement of the jetties or chiefly by dredges?—A. It has been maintained by both. Chiefly by——

Q. From the time that you commenced to notice the deterioration, or when it ceased to scour its channel by its own effort and had to be supplemented by dredging, has there been a gradual deterioration of the channel?—A. Yes.

Q. Can you tell us, approximately, the amount of dredging that has been done each year during the last three or four years or the number of days when dredging has been done? Begin with last year and run back a few years.—A. The average time would be about 100 days each year. Last year 110 days up to the 30th of last June.

Q. One hundred and ten days?—A. At the end of the fiscal year there had been 110 days of dredging.

Q. And how many days the year before?—A. I could not tell you that exactly without the report. I suppose there was not very much difference.

Q. Was there not in 1895 or 1896 over 150 days of dredging?—A. I do not remember. If so, it is shown in my report.

Q. Will you supply us with a statement of the number of days of dredging each year during the last three years?—A. Yes, sir.

Examined by Mr. BERRY:

Q. Do you attribute this deterioration or decrease in scour entirely or chiefly to the loss of the water passing through the South Pass? The difference in the amount of water that passed through at one time being 10 or 11 per cent, and now only 7 per cent—do you attribute that as the cause why it ceased to scour?—A. Well, certainly, if you decrease the volume you decrease the slope and consequently the scouring power of the river.

Q. Do you attribute the fact that it does not scour to the extent that it did the first five years chiefly to the fact that less water passes through the pass?—A. Yes, sir.

Q. Do you believe that the works can be improved at South Pass so as to give a 32-foot channel from the head of the pass to deep water in the Gulf?—A. Just by the action of the current?

Q. Supplemented by dredging, as it is done now.—A. Not safely.

Q. You do not believe that 32 feet of water can be obtained through South Pass?—A. It can be obtained, but the Pass will not be preserved. The amount of water that it would be necessary to put into South Pass to secure a depth of 32 feet would endanger the whole pass. The banks would not stand it.

Q. Suppose the banks would stand it, what estimate would you put upon the cost of getting 32 feet there?—A. That is a matter I have not thought about at all.

Q. Major Quinn stated that for $3,000,000 a 32-foot channel can be obtained there, and that it might be maintained for a cost of $150,000 a year. Do you agree with the statement of Major Quinn?—A. I have not made any estimate of it at all and would not like to make any statement in regard to it. I will say this, however, that a 32-foot channel can be obtained through the South Pass by dredging alone. If I were responsible for it, I would rather maintain it in that way than in any other way. I certainly would not want to put any more water in South Pass.

Q. You would not want to put any more water in the Pass than is now carried?—A. No, sir.

Q. You stated you had no difficulty, when it carried about 10 per cent of the water; but now it only carries 7 per cent, I believe, of the whole amount of the water, and we do have difficulties because the banks have eroded and worn away?—A. I do not think I said we had no difficulty.

Q. I do not know that you did. But you said deterioration began and that you did not have any dredge boats when the Pass carried about 10 per cent of the water, did you not?—A. Yes.

Q. Now, could not the banks be restored or so protected as to carry the 10 per cent that was originally carried when it scoured itself, by the use of a dredge?—A. The banks can not be restored at all after they are once cut away.

Q. You do not think you need any more water in South Pass, then?—A. If you are going to maintain a channel by the current, you need more water in it, but then would come the difficulty of maintaining the banks. The banks of South Pass are cutting very much. There is one matter in connection with the maintenance and the trouble in this pass

that I would like to call attention to. We have experienced the trouble since 1893, mostly. Since 1893 we have had a remarkable stage of the river. Up to the last high river we had had practically no high river for three seasons, and the channel through the jetties deteriorated. We had little rises that brought down heavy sediment, which was carried into the channel and deposited. The current was not sufficient to carry that sediment. I maintain that South Pass has all the water it can accommodate when the river is at flood stage. I make that statement in this report [referring to a report], and whether the Pass a Loutre crevasse were open or closed, if the stage of river that we had in 1894, 1895, and 1896 continued, you can not maintain a channel at the mouth of South Pass or Southwest Pass by the action of the current alone, because it would not be sufficient.

Mr. NELSON. That is, by the jetty system.

The WITNESS. Yes, sir. We can not depend upon having such rivers as we had last year or as we are having now. During a period of two or three years we had not had such a river, and the channel shoaled up greatly.

Examined by Mr. NELSON:

Q. Then, if I understand you correctly, Mr. Donovan, your testimony on that point amounts to this: That at low stages of water, such as you had during the periods you have mentioned, any jetty system would be insufficient, either at the South Pass or the Southwest Pass?—A. Yes, sir.

Q. That you would necessarily have to rely on dredgings?—A. Yes, sir.

Mr. CATCHINGS. In addition to the jetties?

The WITNESS. Yes, sir.

Q. Is it not a matter of fact that within the last three years it has been only by means of a great deal of dredging that the channel required by the Eads law has been maintained?—A. Yes, sir.

Q. It has been maintained chiefly by that and not so much by the natural scouring of the stream?—A. Yes.

Examined by Mr. BERRY:

Q. Chiefly by dredging, did you say, Captain?—A. You might say chiefly by dredging, because if the dredging had not been done we would not have had the channel.

Q. Would you have the same difficulties in Southwest Pass, in regard to the erosion of the banks, that you would have in the South Pass if you undertook to get a 32-foot channel in the Southwest Pass?—A. I do not think so. I think the banks are more stable there.

Q. More stable than in the South Pass?—A. Yes, sir; and then the volume of Southwest Pass would not have to be increased but very little, in my opinion, to secure the necessary water to make the channel at the mouth of the pass through the jetties.

Q. Do you think that by means of the jetties, supplemented by dredging in times of low water, a 32-foot channel could be obtained and maintained through the Southwest Pass?—A. I have no doubt of it.

Examined by Mr. CATCHINGS:

Q. Captain, you do not mean to be understood as saying that the jetties play no part in maintaining this channel?—A. Oh, no; not at all.

Q. Then, if the jetties had not been there, the dredging you have done would not have given you the channel?—A. No, sir.

Q. You simply dredged between the jetties?—A. Yes, sir.

Q. And in any improvement you would have jetties?—A. Yes, sir.

Examined by Mr. BERRY:

Q. Can you make a reasonable estimate of the cost to obtain the character of channel of which you speak in Southwest Pass?—A. I would say (basing my statement, however, upon estimates made many years ago, and work would be cheaper now) that the improvement of Southwest Pass could be made for $6,000,000.

Q. That a 32-foot channel from the Head of the Pass to deep water could be obtained for $6,000,000?—A. Yes, sir.

Q. How wide a channel?—A. Two hundred feet.

Q. A 32-foot channel 200 feet wide?—A. Yes, sir, 200 feet wide at the bottom.

Q. Would that 32-foot channel be ample and sufficient to carry vessels drawing 30 feet of water?—A. Yes.

Mr. GALLINGER. But would your 200-foot-wide channel be sufficient for the interests of commerce, considering the size of modern vessels?

A. I think so. With careful handling of vessels I think it would be sufficient. Two vessels could pass.

Examined by Mr. CAFFERY:

Q. Captain, is it your opinion that Southwest Pass is the better pass to jetty over the bars?—A. Yes, sir.

Q. For navigable purposes?—A. Yes, sir.

Q. You have stated that there was enough water going down South Pass—as much as the banks could stand. Would there be any economy in improving that pass any further by additional jetties, if that be so? Would it not be cheaper to simply dredge and not continue the works there?—A. I think it would be very much better to do the dredging alone in South Pass.

Q. You stated that the banks of South Pass would not stand any greater pressure caused by an additional volume of water?—A. Yes, sir.

Q. And that the jetty plan would not work satisfactorily?—A. Yes.

Q. You think it would work, supplemented by dredging, in Southwest Pass?—A. The jetty plan works entirely satisfactorily at South Pass, but I would consider it entirely advisable to expend more money and improve Southwest Pass, if I were to decide the matter. When you get 32 feet of water in South Pass you have only got a canal anyway, with an average width of about 650 feet, while in Southwest Pass you have a magnificent channel 1,500 feet wide. South Pass is too narrow entirely for the large vessels that come in, even if we had 50 feet of water there.

Q. So your decided opinion is that Southwest Pass is the pass to improve?—A. That is my opinion, decidedly.

Q. And that all that can be done now at South Pass is to keep it open by dredging until Southwest Pass can be improved?—A. Yes, sir.

Q. By dredging and not putting in any additional works there?—A. I would not.

Mr. BERRY. And would it be necessary to divert any more water into Southwest Pass than it carries at present?

The WITNESS. I think so.

Mr. BERRY. You think you would divert some water into Southwest Pass?

The WITNESS. Yes it will have to have a greater volume.

Examined by Mr. NELSON:

Q. As I understand you, then, you think the stage of water that exists in the South Pass is all that the nature of the pass warrants it in carrying?—A. The stage that exists to-day, yes, sir.

Q. And that it would not do any good to increase the volume of water in that pass beyond what it is to-day?—A. No, sir. You probably observed in going up the pass to-day that the banks were nearly full, and in one place it was overflowing a little.

Q. Yes, and I noticed some places where the banks looked weak.—A. Well, those are the places I refer to. If the pass were leveed and a volume of water forced into it those banks would give way, and you would have at least three crevasses that I can assure you of, from that pass into the Gulf.

Q. Then your idea in reference to the securing of a navigable, deep water outlet from the Mississippi into the Gulf would be first to leave the South Pass as it is and simply seek to maintain it by dredging?—A. Yes, sir.

Q. And then improve the Southwest Pass?—A. Yes, sir.

Q. And you would estimate the cost of that at about $6,000,000?—A. I think it ought to be done for that.

Q. Approximately, how many feet of jetties on each side do you figure upon as being necessary? Major Quinn thought it would require 5 miles of jetties.—A. Yes, sir; on either side.

Q. You, too, think it would require 5 miles of jetties?—A. Yes, sir.

Q. Ought the jetties to be made in the same manner as Captain Eads built them, or would you build them in a more substantial and different manner?—A. I would make them different in detail, but substantially of the same character.

Q. Have you taken into account, in your consideration of the case, the two facts stated by Major Quinn—that the distance from the head to the foot of the pass is much longer in the Southwest Pass than in the South Pass; that the character of the lateral current is different; that the angle at which it strikes the axis of the current is different than in the South Pass? Have you taken those two facts into account in your consideration of the question?—A. There is no lateral current, Senator; there is a prevailing current.

Q. I did not mean technically a lateral current, but I mean the tidal movement that goes on in the front of both passes. I referred to that when I spoke of the lateral currents. Now, have you taken those two factors into account in your estimate of the cost necessary in order to utilize the Southwest Pass?—A. Yes, sir; I know all about those two points, but that does not affect my opinion at all.

Q. It would not affect the problem at all, in your opinion?—A. No.

Examined by Mr. SANDERS:

Q. How many years have you been stationed here?—A. Twenty-one years.

Q. And during that time you have been investigating the changes of the pass, and the constant alterations in depth and the state of the banks, almost every day?—A. Yes.

Q. And are thoroughly acquainted with the nature of the work down there?—A. Yes.

Q. Did you have any personal knowledge or any satisfactory evidence of the grounding of the *Montrose* in the Pass? Did you notice that she was across the pass? And did you hear or see the steamer *Sled-*

more pass by her when she was in that pass?—A. No, I did not see anything of that sort.

Q. You were not there at the time?—A. No.

Q. Did you have any report of the risk the *Montrose* ran of being cut down by the steamer *Sledmore*, the close shave she had when the *Sledmore* passed her?—A. No; I did not hear anything of that at all.

Q. You did not hear that she was missed by only four feet by the steamer *Sledmore* when she went past?—A. No, sir.

Q. Do you think that the bar pilots who take vessels through the South Pass are, on an average, good, capable men, who can perform their duty as well as most bar pilots?—A. I do not know anything about the bar pilots anywhere else than here, Mr. Sanders. These pilots, so far as I know them, are good, capable men; certainly those that pilot your ships are.

Q. You would not think that a large percentage of the groundings in the South Pass are due to the negligence of the pilots, or to circumstances that could be controlled by competent pilots?—A. A large percentage of the groundings are not due to lack of water in the channel; I know that. What they are due to I do not know.

Q. You would not presume, then, that it is through some sucking of the banks that these ships are caused to sheer?—A. I would not presume to say anything on the subject, and particularly against pilots. The pilots are good friends of mine, and so far as I know they are competent men; I know the majority of them are competent, reliable men.

Q. Well, I put the question because we ship agents in New Orleans have the impression that the majority of those pilots are reliable and thoroughly capable men, and we have every confidence in them, and their opinion is that the groundings in many cases are solely caused by the very bad state of the channel, that is, its crookedness and occasional lumps, and the difficulty which a vessel has in steering correctly when she is so close to the ground, and I wanted to get your idea as to whether you agree with the views of our captains and pilots in that view of the case?—A. No, sir; I do not agree with them at all. In January I noted two steamers aground (one drawing 19½ feet, the other drawing 22½ feet), and they had left a channel that was 36 feet deep, and the 30-foot channel was 250 feet wide. When I asked what the trouble was I got the same reply: "Why, she took a sheer and wouldn't answer her starboard helm." Now, why she would not answer her starboard helm, or why ships do not answer their starboard helm, I do not know, but I think it would be a very important thing to find out. I do not know what it is due to. Another thing, which you heard me state, about the loading of steamers, that is a very important factor. I have seen steamers go into that pass listed so badly that a man could not walk on her deck. I do not think a vessel ought to be allowed to enter the pass in any such trim.

Mr. NELSON. You have stated that in your opinion the South Pass ought not to carry any more water than it is now carrying, and that in continuing its navigability henceforth you would rely to a large extent on dredging?

WITNESS. Yes, sir.

Mr. NELSON. Is there any immediate necessity, under those conditions, for the expenditure of a large sum of money to close this crevasse in Pass a Loutre if a channel is to be maintained by dredging and you have a sufficient volume of water now?

WITNESS. Well, it is important that that crevasse should be closed, for the benefit of Southwest Pass as well as South Pass.

Mr. NELSON. You think, then, that that crevasse ought to be closed for the benefit of the future improvement of Southwest Pass?

WITNESS. Yes, sir; decidedly. I think it is a very important thing to do.

Mr. CATCHINGS. Is it your judgment that whether the Government undertakes the improvement of Southwest Pass or contents itself with maintaining and possibly improving the channel through the South Pass, that jetties must be made use of?

WITNESS. Yes, sir.

Mr. CATCHINGS. Or can it be done simply by dredging?

WITNESS. No, sir; not by dredging alone. Jetties must be used.

Major MILLER. Captain, in regard to the improvement of Southwest Pass, you suggested a channel, or rather a passage, of 200 feet. You surely did not mean 200 feet, because, in that case, we would not be any better off than we are now.

WITNESS. Two hundred feet, 32 feet deep.

Mr. NELSON. The witness meant 200 feet at the bottom, as I understood him.

WITNESS. Yes, 200 feet at the bottom.

Mr. NELSON. In order to give it the proper slope?

WITNESS. Yes.

The committee then took a recess.

Examined by Mr. NELSON:

Q. I understand you wish to correct your testimony as to the width of the jetties of the Southwest Pass?—A. Some of the gentlemen who heard my testimony have stated to me that their impression is that I gave 200 feet as the width between the jetties at Southwest Pass.

Q. I understood you to mean 200 feet wide at the bottom of the channel.—A. Yes, sir. I did not mean the distance between the jetties would be 200 feet.

Mr. BERRY. You meant 200 feet at the bottom, 32 feet deep?

The WITNESS. Yes, sir.

Q. I think there is a thing you forgot to state. Is it not a fact that about 300 feet or more of the jetties were washed away at the end, after they were constructed?—A. Yes, sir; at the sea end of the jetties.

Q. On each side?—A. On both sides.

Q. Three hundred feet in length on each side?—A. Yes, sir.

Q. When were they washed away?—A. They were built in August, 1875. They were washed away before I got there. I went there in December, 1876.

Q. And they were washed away before you came?—A. Yes, sir.

Q. And have not been rebuilt?—A. No, sir.

Q. Have any other jetties or training dikes been washed away since you came there?—A. About 150 feet of the west jetty was washed out.

Q. At the end of it?—A. Yes, sir.

Q. Since you came there?—A. Yes, sir.

Q. Has that been replaced?—A. Not yet.

Q. Have any of the dikes or jetties at the Head of the Passes been washed away since you came there?—A. Yes, sir.

Q. How much?—A. What is known as the east dike.

Q. Next to Pass a Loutre?—A. No, next to South Pass. That formed the artificial east bank of South Pass going down the river. That washed away many years ago.

Q. How much washed away?—A. 1,250 feet.

Q. 1,250 feet of what you would call the training dike?—A. Yes, sir.

Q. That was washed away when?—A. It washed away from time to time for about three or four years. The last of it washed away about 1888.

A. Prior to 1888, 1,250 feet of the training dike on the east side of the outlet of the Pass had washed away?—A. Yes.

Q. And has never been replaced?—A. No, sir.

Q. There is then, in fact, not much of any training dike left on that side, is there?—A. No, sir. It is not necessary.

Q. It is practically all washed away?—A. Yes, sir.

Q. Even the portion that was washed away was not necessary?—A. It has not been apparent, since it has been gone, that it was necessary, because we have got along without it.

Q. Why did you not tell about this when you was on the stand before?—A. I was not asked about it, sir.

Q. You were sworn to tell the whole truth. Now, has any part of the training dike on the east side been carried away, at the upper end of the Pass?—A. Of South Pass?

Q. Yes; that is what I am talking about.—A. No, sir.

Q. None of it?—A. No, sir.

Q. No part of that part that was connected with the mattress sill in Pass a Loutre?—A. Oh! That is another thing. Yes, that is washed out; the mattress sill in Pass a Loutre connecting this abandoned dike—this dike that was of no consequence—that is washed out.

Q. Was the mattress sill connected with the west dike of the South Pass, or was it connected with the east dike?—A. The mattress sill was connected with the east dike.

Q. I understood you that the 1,250 feet, to which you refer, was the west dike in the South Pass (what I call the west dike) on the right side of the channel going downstream.—A. On the left side of the channel going downstream.

Q. The 1,250 feet, then, that was washed away, was on the side next to the Loutre Crevasse?—A. Yes, sir.

Q. That is washed away?—A. Yes.

Q. That training dike?—A. Yes.

Q. Would not the washing away of that leave an opening for the water to run down in Pass a Loutre?—A. Yes, sir.

Q. And if that training dike had been in there would not have been such a draft of water in there and such a diminution of the flow of water into the Pass, would there?—A. They put in another training dike and stopped it completely.

Q. I understood you a moment ago to say that those 1,250 feet had never been replaced. A. They have not; they put it in in another place.

Q. It shut off the flow of the water between the upper dam and the mainland, going into Pass a Loutre?—A. Yes; where the water was going into Pass a Loutre.

Q. Was that what we saw there to-day?—A. Yes.

Q. When was that built—where there are some fresh willows put in to-day?—A. They do more or less work on that every year; they renew it—keep it up. That dike was built in 1894.

Q. Then there was a period of about six years when there was a gap there unfilled?—A. Yes, sir.

Q. Between 1888 and 1894?—A. Yes.

Q. During that time there was nothing at all there?—A. Yes.

Q. Well there was 1,250 feet carried away. Was 1,250 feet replaced? I do not mean exactly in the same spot, but was 1,250 feet of dike put in back of it?—A. No, sir; it was not the same length. The distance was 150 feet shorter. Neither was it the same character of work.

Q. Did not the training dike on that side of the channel extend way above the mattress sill, upstream?—A. I do not understand you, exactly.

Q. Well, you know where the mattress sill crosses Pass a Loutre?—A. Yes. No; the dike did not extend above the mattress.

Q. Never did?—A. No, it only extended to it; made a junction with it.

Q. Is there not a gap to-day between the end of the mattress sill and the end of the bank or dike on the east side?—A. Yes.

Q. How big is that?—A. Eleven hundred feet in length.

Q. That is a part of the gap that was covered by the old dike that you spoke of in the first instance?—A. Yes.

Q. Then there is a space of about 1,100 feet there that is uncovered really?—A. Yes.

Q. Of the old dike?—A. Yes.

Q. Uncovered by any dike at all?—A. Yes.

Q. And that is where the water flows into Pass a Loutre?—A. Yes. It flows into Pass a Loutre also over the mattress sill that still remains.

Q. Yes, but there is a piece of 1,100 feet with nothing at all to restrain it.—A. Yes.

Q. That was once restrained by a dike that was put in prior to 1879?—A. Yes.

Q. So the jetties there have not been kept up to the condition in which they were left in 1879 when the work was accepted?—A. No, sir.

Q. Now, then (you know and I do not), if there are any other portions of those jetties or dikes that were put in which have been carried away since then, I want you to tell us once and for all and not hold anything back.—A. Senator, I have no desire to hold anything back.

Q. No; I do not say you do. Now you know and I do not, and I want you to tell this committee whether there are any other spots of either jettying or training dikes or any other works that were put up there that have been carried away or destroyed?—A. The upper dam at the Head of the Pass is the principal work at the head of the pass. You noticed that dike crossing toward Pass a Loutre. That is the principal work by which the channel in South Pass is maintained.

Colonel GILLESPIE. What was the object of that straight dike east and west, that runs out at the termination of the present jetty that we find there?

The WITNESS. The object of it was to divert the water from Pass a Loutre into South Pass.

Q. Now, would not that object be destroyed to any degree if there was a gap left there of 1,100 feet?—A. This dike—I have forgotten the length of it—anyway there is only a small portion of it left; the remaining portion is, I think, 550 feet long. It was originally more than three times that length. While that dike was in operation Mr. Eads contemplated putting a sill across South Pass, because there was too much water going into South Pass, it was tearing the banks away. But this work gave way. That is what caused the water to go into South Pass.

Colonel GILLESPIE. Which work do you mean?

The WITNESS. At the upper dam. This work gave way. A great deal of it washed out. That obviated the necessity of putting a sill across Southwest Pass. What caused the flow into South Pass was removed by this work going out.

Q. So there was too much water put into South Pass in the beginning?—A. There was too much at one time; yes, sir.

Q. And the carrying away of this work cured that?—A. Cured that.

Q. And since then there has not been too much or too little?—A. There has been too little at times, and too much at other times. There was too much water in South Pass last year when the river was 19 feet at Carrollton, because it was going all over the country. I consider that the water outside of the banks of the river is an injury to the natural bank. All that South Pass requires is a bank-full stage, and it will maintain a channel at the mouth of the river without any trouble. That is what I claimed in my last annual report, and the effect of the last high river bears me out in my statement; because, whereas for two or three years previously we simply had a slot through the jetty channel, it was very hard work to find out that there was a central depth of 30 feet. That channel improved with the last high river, so that in May, 1897, the least width of the 30-foot channel was 150 feet.

Q. At the head?—A. Through the jetties at the sea end.

Q. I was referring to the upper end—the upper end of the Pass; that is where the dike was carried away, and the dam you refer to, is it not?—A. Yes; the upper end of the Pass was equally improved by the high water.

Q. Has any other part of the jetty work, or the dike work, or dam work that was originally constructed been carried away or destroyed, except what you have stated?—A. Yes, sir; about 500 feet of the mattress sill across Southwest Pass.

Q. What is the condition of the jetties at the lower end, toward the outlet—for there is where the jetties proper are, anyway?—A. The Gulf end of the jetties?

Q. Yes; what is the condition of the jetties themselves? In what state of preservation are they?—A. They are in a good state of preservation at the present time.

Q. How long are they likely to last without any replacement?—A. The only trouble about the jetties down there is the settlement of the country. That country is settling all the time.

Q. The whole country?—A. Yes, sir.

Q. And the bed of the stream, too, I suppose, with it?—A. I suppose so.

Q. It all settles?—A. I know the country is settling.

Q. How much of a settling has there been within the last four or five years?—A. I can not tell you that, Senator.

Q. Have you made any attempt to ascertain?—A. We have made observations that will give us that approximately.

Q. What do those observations show has been the amount of the settling?—A. I can not give you the figures. We know that there is a settling going on. This is a very delicate matter to determine, and it is a matter that is in progress now, under the direction of the Mississippi River Commission. It has to be determined by very minute observations.

Q. What do the observations indicate so far? I do not expect you to be exact.—A. They indicate a settlement of the whole Mississippi delta.

Q. To a material extent?—A. Yes; I should say so.

Q. Well, give us some idea in feet or inches, by years.—A. I will give you an idea in this way: When the plane of average flood tide for the reduction of our soundings down there was established in 1875, by three months' observation it was found to be 2.76 on a certain gauge. That plane of average flood tide to-day is 4.1 feet.

Q. How much difference is that?—A. That is 1.34 feet.

Q. In how long a period?—A. From 1875 to 1898. Twenty-three years.

Examined by Colonel GILLESPIE:

Q. I want a little definite knowledge as to the reason why this construction has been made at the upper end of that island, on the right bank as we came up the channel. It is in the shape of a letter "T," with spurs on each side, with a branch running east and west at the end of the prolongation of that island. You know what I mean, do you not?—A. It was on the left when we came up?

Q. On the right, opposite the light-house?—A. On the right coming out of South Pass?

Q. Yes. We passed around it in going down to the crevasse. There is a long east-and-west dike there.—A. Yes.

Q. For what reason was that long dike built?—A. That is the original upper dam.

Q. You stated a few moments ago that there was a period in the construction when Mr. Eads thought there was too much water going down the South Pass?—A. Yes.

Q. Was that construction put in there for the purpose of restraining that water?—A. No. On the contrary, it was put in for the purpose of increasing it. That was the time when that dike was three times as long as it is to-day—more than three times as long.

Q. Longer, in the same direction it now is?—A. Yes; in the same direction, extending over to Pass a Loutre, much farther.

Q. What destroyed that dike? Is that the destruction that you referred to?—A. The flow into Pass a Loutre required more room, and the Mississippi simply took off enough of that dam to accommodate itself, as it will do in every instance.

Q. Then it was the flow into Pass a Loutre that took off the east end of that dike?—A. Yes, sir.

Q. Has the dike a direction which would give an increased flow into South Pass?—A. Yes, sir; that dike will create a backwater above the head of South Pass and make a draw into South Pass.

Q. Then it is simply by increasing the head and giving a flow around to the westward?—A. Yes.

Q. It has no direct effect?—A. It does not draw the water directly in.

Q. It does not draw the water directly in, but dams up the water and throws it around on the west side?—A. Yes. A work that would apparently throw the water into South Pass would throw it right across South Pass into Southwest Pass, so it was simply to create a head of water and to draw it into South Pass.

Q. His intention, then, was not to prevent the destruction of the northern end of that island?—A. No; not at all.

Q. There was no tendency to wear that island away?—A. No.

Q. And he simply wanted to produce an increased head and then throw it around on the other side?—A. Yes.

Q. Now, what tendency was there to throw the water to the westward rather than to the eastward by a construction of that kind?—A. I do not know that there was any tendency to the westward.

Q. Then there was not any utility in his building that dam there. If the purpose was to dam up the water and throw it to the westward, why was the tendency to the westward rather than to the eastward?—A. By creating this head above this dam, it made a fall from the water

above to the water going into the South Pass, and drew the water in there.

Q. Was the shortest distance through the South Pass at that time to the Gulf?—A. Yes.

Q. Then the draw would have been in that direction?—A. Yes.

Mr. GALLINGER. You advocated the opening of the Southwest Pass as the chief commercial highway. Do you know of any engineering difficulties in the way of making that an entire success?

A. I do not know a single one—not the slightest.

Mr. GALLINGER. Do you agree with other engineers in that view? For instance, do you fully agree with Major Quinn in that view?

A. I can not say that I agree with Major Quinn, for, as I understand it, Major Quinn says that you can not obtain thirty-two feet at Southwest Pass.

Mr. GALLINGER. Then you may be right or wrong, or he may be right or wrong, in the view that is held on that point?

A. Yes, sir; I may be right or wrong.

Q. Is the extension of that dike work on the east side of the channel sufficient to give all the draw of water into South Pass that is necessary? Would any extension to the northward be necessary, in other words? Would it be necessary to replace that quantity of the dike work that has been destroyed?—A. According to present indications it will not be nceessary.

Q. Then the construction at the head of that island, as we saw it to-day, is sufficient to give all the flow that you can practically get from the Mississippi River?—A. Entirely sufficient. It throws all the water into South Pass that South Pass can carry at high stage of the river. You noticed, perhaps, in coming up South Pass to-day, that the banks were full. Any increase will overflow those banks, and that is useless.

Q. Then it is not necessary to throw any more water into that channel as long as the banks remain as they are?—A. No; not at high river. At high-river stage there is sufficient water.

Q. Will it be practicable to protect those banks in a way that will be beneficial by an extension of the works at the head of that island, so as to give an increased flow through that channel?—A. Yes, sir; it is practicable.

Q. By practicable, of course, I mean at reasonable cost.—A. I should say, no.

Q. Your opinion, then, is that it would not be practicable to do anything like leveeing of the present South Pass?—A. It would be practicable to do it, but it is extremely inadvisable in my mind.

Q. For what reason?—A. For the reason that the banks at South Pass will not stand the erosion of an increased volume of water.

Q. That erosion would have a tendency to enlarge the cross section?—A. Unquestionably.

Q. And there would be no object in enlarging the cross section as long as the cross section remains as it is at the bar?—A. There would be no object in increasing the cross section of the Pass above the jetties at all beyond what is in the jetties.

Q. That being the case, as long as the present cross section of the bar remains the same, you can not enlarge the cross section of the Pass?—A. It would not be advisable.

STEAMER WHITNEY (MORGAN LINE),
Below New Orleans, La., February 9, 1898.

W. P. ROSS testified as follows:

On behalf of the New Orleans Executive Committee now working for improvement at the mouth of the Mississippi River, I desire to lay before you their reasons for believing that South Pass is inadequate, under the utmost possible or practical improvement, to provide the necessary channel for the most economical tonnage of the present day, and unquestionably so for the tonnage which will be the ocean carrier of the near future. We might say that no better confirmatory evidence is wanted than the fact that New York, Boston, and such leading European ports as Liverpool, are reaching out to provide channels 35 feet deep and of sufficient dimensions otherwise to accommodate steamers 900 feet in length and 80 to 100 feet beam.

Twenty-five years ago (when the present jetty channel was planned) we knew comparatively little of what was possible in the development of ocean tonnage. Then a steamer 300 feet long was a large one, and there were few as high as 40 feet beam, and still fewer drew as much as 25 feet of water; furthermore, it was then supposed that the contract for the jetties called for a channel 30 feet in depth, and even when it was modified to 26 feet the alarm was not taken; in fact, few people knew of that modification, while probably no one outside of the contractors themselves realized that the 26 feet of channel provided was from the plane of mean high tide, subject to shoaling and fluctuation through wind and tide. In ascertaining the contract channel, as we understand, soundings are taken from the plane of mean high tide (that is, from a point or bench mark so fixed, which might be 3 feet above the surface, in the air). There may thus be at neap tides, with north winds blowing, but 23 feet of actual water, instead of the 26 feet of water to which the Government engineer is compelled by terms of contract to certify as existing.

It is probable, had these facts been known or understood, Mr. Eads's contract would have read so that a minimum channel of 26 feet would have been assured at all stages of tide and wind. Even this would have been inadequate for the present economical freight carriers now in the trade, such as the *European*, 475 feet long, 55 feet beam, requiring a channel 32 feet deep, of ample width, for safe and easy navigation. By safe and easy navigation we mean that a ship which will draw 30 feet on even keel in salt water will draw 30 feet 7½ inches in fresh water; that nine ships out of ten would be trimmed 1 foot or 18 inches by the stern, and further require at least one spare foot of water under their keel, even in the jetties, where there is no chance of swell or sea. A ship, therefore, drawing 30 feet water even keel in salt water, or 30 feet 7½ inches in fresh water, will trim in fresh water 30 feet forward and a little over 31 feet aft. As the *European*, *American*, *Milwaukee*, *Montrose*, *Monmouth*, *Montcalm*, and *Monarch* are ships of this class, it needs no further argument to show that the present jetty channel, even if improved to 32 feet, would be barely equal to the most economical freight carrier now in the New Orleans trade.

That it is not equal to the modern freight carrier, with which New Orleans has to compete, is shown by the fact that the steamship *Cymric* is 599 feet long, 64 feet beam, and 38 feet depth of hold, while the *Kaiser Wilhelm der Grosse* is 625 feet long, 66 feet beam, and 43 feet depth of hold, and still larger steamers are in course of construction.

A channel of 32 feet in depth would therefore be inadequate for

steamers actually in existence, much less to the still larger ones which will doubtless be built during the next few years, and which will be able to carry cargo still cheaper than at present. That these will be built is undoubted, if only from the fact that competition among the various freight carriers will unquestionably cause response to the demand for more economical transportation wherever facilities are provided for the larger ships necessary. Shipbuilders all agree that economy in construction depends upon the depth and length of the boat; that increase in beam of the vessel, whereby lighter draft may be had, adds to the cost of construction, considerably out of proportion to the added cost of making the ship deeper and longer.

Another practical reason why shipowners object to a channel where they are liable to strandings, collisions, etc., is from the fact that every such accident means an expenditure of large sums of money. The stranding of the *Barbara* involved a loss to the ship and cargo of over $100,000; but at the least every stranding involves detention.

The usual method of reckoning detention is at 8 cents per ton net register per day. The *Milwaukee*, carrying 27,000 bales of cotton, is 4,755 tons net, which at 8 cents per ton is nearly $400 per day. The interest on her cargo at 5 per cent runs to nearly $30 per day. In addition to this, towage expenses are incurred in almost every case of touching the ground ranging from $500 to $10,000 or $15,000, as towboats for this service charge, according to size, from $20 to $30 per hour, and sometimes three or four tugs are needed; besides this, every vessel stranding blocks others from coming in and going out. It is not an overestimate to say that recent strandings, commenced by the *Ramore Head*, about six weeks ago, cost in detention, towage, and interest a full hundred thousand dollars, while the consequential damages can not be estimated. We do not know what markets have been lost through delays in delivery of cargo, although these occasionally come to our attention, and one case was brought recently to our notice which cost the receiver on the other side about a thousand dollars on a small parcel of grain, and doubtless this case is only one of many.

Again, the agents loading steamers at this point have been made overcautious by the uncertainty of the steamships getting out, and in many cases have advanced their grain rates to a prohibitive point in order to give preference to cotton and other light cargo. The effect of this reacts through the country, so that although the cause may be unknown, these strandings in South Pass have affected the grain movement, and consequently the prices in the interior.

There is one thing also certain, and it is that you can not put an expense upon a shipowner which he does not in turn impose upon the producer. The shipowner is after net revenue only, and every item of expense—even such extraordinary ones as just mentioned—are practically allowed for in the gross rate of freight which he demands. The underwriter also adds his little mite in the way of increased premiums on the ships and cargo. He, like the shipowner, figures all these contingencies in his rate.

There is a further reason why South Pass is a standing menace to ships inward bound.

In thick weather vessels are thrown to the westward through an unmistakable current trending west past the end of the narrow jetty channel. The consequence is that they get ashore west of the jetties, at a point where, from various causes, a dangerous, hard shoal has accumulated. More than one vessel has been lost here, and others seriously injured, such as the *Chas. Luling*, *Gottfried Schenker*, and

Breakwater, among many others. The *Gottfried Schenker* contributed 1,000 tons pig iron as her share to this dangerous shoal. At Southwest Pass, with an entrance probably 1,500 feet wide and no shoal to the westward, this danger disappears.

As an example of how shipowners and underwriters look on these constant strandings in South Pass, I would quote from a letter just received from the managers of the Head Line, whose steamers *Ramore Head*, *Inishowen Head*, and *Malin Head* suffered expense and detention since the 1st of January. They write:

We confirm cables exchanged and note that you have now compromised the *Ramore Head* towage for ———. We certainly think that both of these firms have been amply remunerated for their work. Of course we can not pay a sum of this kind out of our own pockets, and are therefore having average bond perfected and the amount will constitute a general average claim upon the ship and cargo. It is very unfortunate, but can not be helped. We have no doubt whatever that you have done your best to reduce the claim, but all these things tell with underwriters against New Orleans. You can have little idea how it is canvassed here, these continual groundings, heavy expenses, and long detention.

Coming now to the question of width of channel: In the navigation of ships, it is manifest that in a narrow channel with a swift current vessels are at any time liable to take a sheer into the bank. Many of the strandings in South Pass have been from this cause. That is one disadvantage of a narrow channel. The next difficulty in a narrow channel is the increased risk of collision. Where we had formerly to deal with ships 35 to 40 feet beam and only 300 feet long, the present channel was not so far out; but now that we have to deal with ships of 45 to 55 feet beam and lengths 400 to 500 feet, there is manifestly more difficulty in navigating this same narrow channel; while to deal with ships 800 or more feet in length and 60 feet beam, it is manifest that these difficulties will be again enormously increased.

As examples of what is meant, I would instance the steamship *Barbara*, grounded last year in South Pass during high water, with a 6-mile current running. Her propeller and rudder were disabled and twisted out of shape, and it was found impossible to tow her in this condition upstream, stern first, to the Head of the Passes. Although she is only 340 feet long and was drawing but 24 feet, it was necessary to drive piles alongside the banks, to which the ship could be secured, and then lighten her of 1,000 tons of cargo before she could be winded round bow up upstream. In the case of the *Ramore Head*, 402 feet long (which steamer grounded about a month ago at Grand Bayou), she had to be towed upstream after being floated to the Head of the Passes (about 6 miles) stern first, because she could not turn round and steam up.

There is evident danger in towing a ship stern first against a fast current, and it is impossible if the propeller and rudder are disabled, as was the case with the *Barbara*. Had the *Ramore Head* been so disabled it would have been necessary to lighten her and take her to sea before she could have been turned round and towed back to the city for repairs. This question of turning a ship around in the Pass is something liable to be required at any time, especially in a channel 12 miles long, and it is plain that such a feat is not possible unless the channel is as wide as the ship is long; that is, with a ship drawing 30 feet of water, 500 feet long, there should be a 30-foot channel at least 700 feet in width at the bottom, in which she could be freely turned, and this necessity grows with the length and the depth of the ship.

Another reason requiring width of channel is the fact (in which all nautical men agree, although it may be a chestnut) that an accident which will result in the sinking of a vessel is bound to occur sooner or later.

Possibly, when this inevitable collision does come, there will be two vessels sunk. It is improbable that such vessel or vessels will lie fair up and downstream, but are more liable to get athwartship, and may occupy pretty near the whole width of the channel or as much of it as that ship's length will go. Now, a vessel in such a position would speedily so fill herself with sediment that little short of dynamite would be effective, except possibly the slow process of breaking the ship up into pieces and removing her plate by plate. While dynamite would doubtless blow the ship up, it would blow the channel with it by destroying the extremely narrow banks. Such a wreck would completely stop the channel for a twelvemonth, and New Orleans would be as well bottled up and ruined, for a seaport, as if it were located at Kansas City.

There is but one effective remedy for this, and it is that the channel must be sufficiently wide for any vessel to be sunk and still leave space, on one side or the other, for other long, wide, and deep vessels to pass. Under such circumstances even 600 feet width of channel would hardly be sufficient. This is not a fancy sketch, or a false cry of "wolf," but one which will be borne out by the expectations of experienced seafaring men the world over, with expressions of wonder that it has not occurred before.

Having thus described at length what the ships require and expect (now and in the future) for easy and safe navigation, I would next draw your attention to what we have at South Pass and compare same with Southwest Pass. We take the stand that a channel 35 feet deep and 800 to 1,000 feet wide at the bottom, at all stages of the river, is necessary for easy and safe navigation. At South Pass we have a channel 12 miles long from the Head of the Passes to the sea end of the jetties. It is approximately 600 feet wide throughout at the surface, with a nominal channel 26 feet deep and 200 feet wide at the bottom. At Southwest Pass we have a channel perhaps 15 miles from the Head of the Passes to deep water, but it is nearly three times as wide as South Pass, or some 500 feet wide, throughout its entire length up to about the light-house, where it commences to widen out. From this point to the 10-fathom curve in the Gulf it is about 6 miles.

From the Head of the Passes to the pilot station the channel throughout runs 40 to 50 feet deep and about 800 feet wide at the bottom. The natural conditions, therefore, are that Southwest Pass would have a channel wide enough and deep enough for all purposes; so that with the exception of the necessary works (which are common to both South and Southwest Pass) needed at the Head of the Passes and the jetty works at the mouth of Southwest Pass, nothing further would seem to be needed for easy and safe navigation through Southwest Pass.

At South Pass the conditions are altogether different. The entire channel, 12 miles long, the jetties themselves, and the works at the Head of the Passes, would all have to be widened and deepened throughout the entire length. Engineers tell us that the banks of South Pass are not strong enough to support themselves if the channel is deepened to any great extent. As we need a channel 800 to 1,000 feet wide at the bottom, it is necessary to have a channel 1,500 to 2,000 feet wide at the surface and carrying a much larger volume of water than at present. Doubtless the works at the Head of the Passes can be enlarged and widened so that any amount of water can be deflected into South Pass, but what can be done with the jetties themselves? If the Pass is widened and deepened as required the volume of water that will be necessary to scour out the Pass will be so great as to erode a channel through the jetties at least 40 feet deep. It seems plain that such a channel

would undermine the works, and all the rock and stone, etc., now composing them slide into and destroy same. The works throughout South Pass, from the head and including the jetties, were all designed for a channel less than 30 feet in depth. Thus, at South Pass, the entire gut (it is nothing more), 12 miles long, would have to be widened and excavated, and when it was done there would be a very great risk that the value of the work would be destroyed through this undermining of the jetty works themselves.

At Southwest Pass we have none of these difficulties to encounter. We think it is simply the problem of contracting and extending the banks for less than 5 miles into deep water and incidental dredging. Whether there are engineering difficulties about this which would make the work impracticable, is something of which we are not competent to speak. The surveys now called for are to establish this fact by competent testimony. We consider that our duty is limited to pointing out to you the difficulties and shortcoming of the present channel and the difficulties we see in making South Pass available for what is now so badly needed and what must become more and more necessary with each year.

In conclusion, there is a final reason why the channel out of the Mississippi River should be sufficient for the most modern of the world's navy, present and future, and a reason in which the entire country is interested. At present there are few harbors where the larger vessels of the United States Navy could seek refuge in case of overpowering necessity, and none in the Gulf. The Mississippi River itself affords a harbor that can accommodate, in single file, something like 1,500 of the largest vessels in the world, as in the lowest water there is ample depth in the channel for 200 miles above the Head of the Passes. This harbor is landlocked and the entrance to it could be obstructed with the greatest ease against the entrance of any foe.

In case of war with the countries to the south of us, or in fact with any foreign country, New Orleans would be one of the bases of operations, provided this channel at the entrance of the river was made adequate. The natural causes, which would even compel this, lie in the fact that it is not only a large city and seaport, where every requisite incidental to military and naval operations can be concentrated, but it is the terminus of the greatest river in the country, and it is also the terminus of the largest number of important trunk lines, not even excepting New York, and as a concentrating point thereby unequaled. It is the only large harbor where ships can lie in fresh water and is therefore, par excellence, the best point where the navy held in reserve could be laid up, so as to be in such a place that when wanted for service in an emergency, they would not require detention in docking, cleaning bottom, repairs, etc., which matters, while apparently trivial, are very important in actual practice.

I would wind up with a statement of the steamers grounded in South Pass during 1896, 1897, and up to January 31, 1898:

Memorandum of steamers grounded in and about South Pass, Mississippi River, during 1896, 1897, and January, 1898.

1896.

Two steamers were grounded in Grand Bayou Reach and one steamer was grounded about 1½ miles above South Pass light-house.

Mar. 20. Steamship *Montezuma*, 25 feet, grounded about 1½ miles above South Pass light-house.

Apr. 21. Steamship *Iona*, 25 feet, grounded in Grand Bayou Reach.

Apr. 25. Steamship *Nordhvalen*, 23½ feet, grounded in Grand Bayou Reach.

1896 AND 1897.

Fourteen steamships and one ship grounded, as follows:

1896.

Sept. 27. Steamship *Galiego*, 23 feet, grounded head of South Pass.
Oct. 15. Steamship *Alberta*, 25½ feet, grounded opposite West Light.
Oct. 21. Steamship *St. Jerome*, 19½ feet, grounded 2 miles below head of South Pass.

1897.

Feb. 12. Steamship *Louisiana*, 17 feet, grounded 1,000 feet beyond end of west jetty.
Apr. 17. Steamship *Barbara*, 24½ feet, grounded 500 feet below South Pass light-house.
Apr. 27. Steamship *Aco*, 24⅞ feet, grounded Goat Island Reach.
May 5. Steamship *Principessa Christiana*, 20½ feet, grounded at entrance to jetties.
May 27. Steamship *Rhoetia*, 24⅛ feet, grounded in Grand Bayou Reach.

During the month of June there were four steamers grounded in Grand Bayou Reach, names unknown, drawing from 23½ to 25 feet.

JUNE 30, 1897, TO JANUARY 31, 1898.

1897.

Oct. 8. Steamship *Inchisle*, 24 feet, grounded in Grand Bayou Reach.
Dec. 28. Steamship *Ramore Head*, 25⅛ feet, grounded one-fourth mile below Head of Passes light-house.
Dec. 28. Steamship *Berenicia*, 25 feet, grounded between Grand Bayou and Goat Island.
Dec. 29. Steamship *Carolina*, 22½ feet, grounded one-fourth mile below Head of Passes light-house.
Dec. 30. Steamship *Duchess of York*, 19½ feet, grounded one-fourth mile below Head of Passes light-house.

1898.

Jan. 8. Steamship *Montezuma*, 25¼ feet, grounded in Grand Bayou Reach.
Jan. 10. Steamship *Breakwater*, grounded east jetty (entering).
Jan. 13. Steamship *Galiego*, 22½ feet, grounded Grand Bayou Reach.
Jan. 15. Steamship *Montrose*, 24½ feet, grounded Grand Bayou Reach.
Jan. 16. Steamship *Montezuma*, 25¼ feet, grounded Grand Bayou Reach.
Jan. 22. Steamship *Beltislon*, 22½ feet, grounded Grand Bayou Reach.

This list does not include a vastly larger number of vessels that were detained, some for a number of days, until the channel was cleared.

Q. What is the length of time required for the navigation from the Head of the Passes to the Gulf?—A. It depends on circumstances. It is 12 miles. Some ships go slow and some go faster.

Q. What is the average length of time?—A. I suppose the average time would be about two hours; perhaps three hours, if they are going slow.

Q. How many vessels on an average use that channel per day?—A. I believe there are about 1,200 steamers, large and small, go out of New Orleans every year. That would be about 4 in and 4 out daily the year around, outside of tugboats and vessels of that class.

Q. Is a record kept of the vessels passing in and out of South Pass?—A. All vessels that enter and clear from New Orleans use that Pass.

Q. And the record shows, according to your statement, that 4 vessels pass in and 4 vessels pass out per day?—A. I think, about that.

Q. Would it be any great hardship to place this channel under the guardianship of the United States Government, say, so there should be but one passage each way daily?—A. Yes; because they have to take their turn for the tide, wherever there are several large vessels of deep draft, and it would only allow about 1 vessel per day on that theory, if they drew much water.

Q. How much is the average tide?—A. The tide is supposed to be a foot. The wind influences it a great deal.

Q. Does the wind interfere very much with the draft of a vessel, or the tide?—A. Yes, sir.

Q. Now, I repeat my question: Would it be a very great hardship to

require that there should be but one single passage either way?—A. Yes, sir; for this reason, that in the winter time (while this average may be 4 a day the year around) there may be 12 to 20 in one day going out, and as many coming in.

Q. Can you state any particular day in which there were 12 or 20 steamers used this channel?—A. We have a number of times this winter had 12. I think one time we had 17 steamers clear in one day.

Q. Can you cite any particular day in which there were 17 vessels, or even 12, that used this passage in one day?—A. I could not cite the date, but I think I could find it by looking up the clearing records.

Q. Then you make the statement without looking up the records?—A. Yes; I make the statement from memory. I have noticed, I think, as high as 17 steamers clear in one day.

STEAMER WHITNEY, MORGAN LINE,
Below New Orleans, La., February 9, 1898.

Mr. SANDERS. Mr. Chairman, we are very desirous of having Major Harrod give us some testimony on this matter; and if you will permit me, I would like to preface his evidence with a letter received, at my request, from himself and Colonel Richardson, when our committee was considering the petition which we should place before Congress. We had had considerable consultation as to whether it was advisable for us to ask the Congress to improve the present Pass or whether we should ask the improvement of the Southwest Pass; and in that connection we endeavored to obtain evidence of competent engineers to give us their expert guidance in the matter, and we wrote to Major Harrod and Colonel Richardson, asking them to be kind enough to express their opinions on the feasibility of improving the present Pass to make it suitable for modern tonnage. This is their reply, if you will permit me to read it.

Mr. NELSON. Yes, sir.

Mr. SANDERS. It is addressed to me and is as follows:

NEW ORLEANS, LA., *January 5, 1898.*

Mr. M. J. SANDERS,
Chairman Executive Committee General Conference on Improvement of Channel at Mouth of the Mississippi River.

DEAR SIR: In reply to your request for our opinions as to the practicability of improving the present channel through South Pass by an increase of its depth and width, we would make the following statement:

The works for the improvement of the South Pass at its head and bar contracted its cross section and extended its length, and thus tended to diminish its discharge. It hence became necessary, in order to preserve the normal proportion of the discharge which was required for the proposed depth, to give the works at the Head of the Pass a funnel shape, and to throw sills across the competing Passes.

It will thus be understood that it is only by maintaining the adjustment, as originally established by Mr. Eads, with great skill and cost, that the constant struggle of the two larger Passes to rob South Pass of a part of its discharge has been thwarted.

But, within the past four or five years, this adjustment of the volume of discharge between the several Passes has been disturbed by the loss of a part of the work designed to deflect the flow from Pass a Loutre into South Pass, by the recession of the right bank of the former Pass, the flanking of the sill across its head, and the opening of the crevasse into Garden Island Bay. These changes have given an increase to the discharge of Pass a Loutre which has been largely taken from South Pass. The latest gaugings of which we have information give the percentage of discharge through the three Passes—Southwest, Loutre, and South, respectively—at 41, 52, and 7, against about 45, 44, and 11 at the inception of the work on the South Pass jetties. It thus appears that South Pass now has less than two-thirds

of the volume and energy of current which was considered necessary for the results contemplated, and for which the works of improvement were designed, viz, a 200-foot channel 26 feet deep into and through the Pass, with a central depth of 30 feet through the jetties and over the bar.

Under these conditions your question may be considered as resolving itself into the following shape: Is it practicable to take South Pass in its present state of decadence, when the requirements of the law—for reasons that are quite clear and natural—are with increasing difficulty complied with, and give it a capacity far exceeding its original dimensions or the intent with which the works of Mr. Eads were designed? We think not.

Notwithstanding the great success of the jetties and their thorough adaptation to the requirements of the ships of twenty years ago, it seems to us impracticable to enlarge the dimensions of South Pass to either the width or depth demanded for the commerce of to-day. No port is sufficient for this which will not at all times of the tide admit ships 600 feet long, drawing 30 feet, for which will be needed through the pass a 32-foot channel 400 feet wide, and through the jetties and over the bar a 35-foot channel of still greater width. The Pass itself should have a width of not less than 1,000 feet between banks.

The difficulty in obtaining the depth above mentioned in South Pass would be that of controlling a proportion of the river's discharge which would be sufficient to scour or even maintain it, and the danger in getting the width that the banks would be so weakened and lowered that breaches through them would be imminent.

The advisable course is the immediate beginning of the improvement of Southwest Pass, and until sufficient results are obtained there to maintain the channel now required by law in South Pass.

Very respectfully,

B. M. HARROD.
HENRY B. RICHARDSON.

STEAMER WHITNEY, MORGAN LINE,
Below New Orleans, La., February 9, 1898.

B. M. HARROD, recalled, testified as follows:

The WITNESS. I have never had any official connection with this work of the improvement of the Passes of the Mississippi River. My interest in it is that of an engineer and citizen of New Orleans. I have followed the work as closely as I have had the opportunity since its inception.

I assume that it is the intention of the Government to make this one of the first-class harbors of the country; a harbor that will admit any vessel that has been built up to this time or that will be built within a reasonable time in the future. I think a fair demand for such a port is that through the Pass and through the jetties a depth should be maintained sufficient for vessels 600 feet long, of 30 feet draft, with corresponding beam. I think the channel should be, for a width of 500 feet, over 32 feet in depth, which would give a greater central depth. As you approach a point in the jetties to which the swell of the sea reaches, the depth and width should be increased until over the bar itself you have a depth of 35 or 36 feet and a width greater than 500 feet. A width of 500 feet and depth of 32 feet would, of course, give a greater central depth; and that greater central depth I think is necessary. Thirty-two feet as a maximum would not be sufficient, but a 32-foot depth and a 500-foot width would give a central depth which I believe would be sufficient.

Mr. NELSON. What would you estimate the central depth in such a case as that?

The WITNESS. I should suppose it would run up to fully 34 or 36 feet; but that would only be the thread, or thalweg, of course.

Mr. NELSON. Yes, I understand.

The WITNESS. I am generally of the opinion that the cause of the decadence of the South Pass, as far as it has proceeded, is the loss of

the proportion of the river's discharge for which the works originally were designed.

Mr. NELSON. In this connection I would like to call your attention to Mr. Donovan's testimony a moment ago. Did you hear it?

The WITNESS. I did, sir.

Mr. NELSON. You heard what he said about the construction of that dam at the entrance, that has been carried away, and that was found to bring too much water into the pass, and that since it has been carried away the quantity has been moderate and reasonable, but before that it was found to be too much, and that there is a gap of 600 feet there that is uncovered of that original dam or dike?

The WITNESS. I have great deference for Mr. Donovan's opinion. I know him well, and I know his experience and ripe judgment in the matter. I substantially agree with him, with this limitation: The works were designed to control for South Pass about ten or eleven per cent of the discharge of the river. As constructed they controlled more. Had that proportion of 10 per cent of discharge been maintained in the South Pass, the result to-day would be different. Certain failures which have occurred would have been avoided. Under the conditions existing to-day, since the discharge has been reduced, I am not prepared to say that the safety in restoring it would be quite assured. But I am of the opinion that, had the conditions of control of discharge that existed from 1883 to toward the end of that decade been maintained, the superb condition of the South Pass and the jetties as a channel during that period would have been maintained. I think the reduction of the proportion of the volume of water from ten or eleven down to about seven per cent is closely connected with the failure of the jetties (relatively speaking) in later years. This leads me to say that in any future improvement of the mouth of the Mississippi River absolutely the first thing and the most important thing to do would be to establish such control over the distribution of the total discharge of the river between the several passes as is decided to be necessary for the improvement of any one pass. No matter what pass is to be improved, whether the South Pass jetties are to be maintained or whether the Southwest Pass is to be jettied, or under any other circumstances, I think that is absolutely the first thing to be done and the thing that must be maintained from beginning to end. When that control of the distribution is lost the mouth of the river is in jeopardy.

Examined by Mr. NELSON:

Q. Now, may I suggest one thing to you here, Major? because I want to hear your views on it. According to Mr. Donovan's statement, there is a sufficient flow of water into South Pass now at this stage of water; that it ought not to have any more. Now, that being the case, I would infer from that statement that it is only at low-water stages that you would require a greater inflow. Now, then, how would you bring that about, so as to operate only at the low stages and not at the same time operate at higher stages?—A. You can not do that, sir. You can not treat this river as you would a miner's ditch—sell the water by inches and peddle it out among the different passes—you are obliged to take it as it comes.

Q. Now, then, there is a difficulty that I can not reconcile in my own mind—the difference between your statement and Mr. Donovan's statement.—A. The difference between Mr. Donovan's statement and mine is that the pass having been (as I understand it) to some degree impaired, the discharge has been reduced to about 7 per cent.

Q. As it is to-day?—A. Yes. And my statement is that I believe the pass would be in better condition to-day had the discharge of between 10 and 11 per cent been maintained. But as to restoring it from 7 to 10 now, it is a doubtful and difficult process which I am not prepared to recommend.

Mr. GALLINGER. Why doubtful and difficult?

The WITNESS. On account of the erosion and weakness of the banks, and the danger that would attach to restoring the cross section, the danger which would arise from throwing a larger volume of water into the pass for purposes of scour.

Mr. GALLINGER. But if that larger volume had continued uninterruptedly, would not this erosion have gone on to a greater extent?

The WITNESS. No, sir. By "larger" I meant 10 to 11 per cent, as originally intended. Had that been maintained, the enlargement of channel by erosion would not have continued. Filling commenced when the volume of discharge was allowed to decrease.

Mr. GALLINGER. You have testified that you think we would have been better off if the full amount of 10 or 11 per cent had been constantly kept in this channel; that it has been depleted to 7 per cent, but that in your judgment it is dangerous and difficult to restore the normal amount of 10 per cent.

The WITNESS. I am not prepared to recommend it.

Mr. GALLINGER. And you give as a reason that it would erode the banks. Now, would not the banks have been eroded to a greater extent if this 10 or 11 per cent had been continued in the pass all the time?

The WITNESS. That does not follow. If you undertook to increase the channel now, you might reach that end by the erosion either of the bed or the bank. You might enlarge the cross section in either way, and which would most probably occur I can not tell. If you turned an additional discharge down there, there would be a chance that the bed would not be scoured out by it, but that the banks would be eroded.

Of course the only two courses for maintaining an open mouth to the river are the enlargement of South Pass or the improvement of Southwest Pass. It seems to me that there is absolutely no reasonable choice between them. It is impossible, in my view, to get a satisfactory result in the South Pass. To do that (roughly speaking and with very little thought) would take an increase of channel depth (in South Pass, to make it satisfactory for commerce to-day, or up to the dimensions that I have spoken of before) of 25 per cent, an increase of channel width of 150 per cent, an increase of bank width of at least 60 per cent, and of cross-sectional area 75 per cent.

Q. Do you think that is a fair assumption?—A. It is a fair assumption to bring it up to the standard of channel that I have spoken of before.

Q. No, but upon the facts as they exist to-day, do you think that that is a fair assumption—that that is an assumption of fact, I mean—that there is a 26-foot channel?—A. I think it is for the use that I was going to make of it. You have not heard me through.

Q. Well, go on then.—A. I was going to say that, assuming that there was 26 feet depth through the South Pass to-day, that to increase its dimensions to the figures I have mentioned would require the removal of over 20,000,000 cubic yards of material.

Mr. CATCHINGS. And if the channel is not 26 feet it would require more, would it not?

The WITNESS. Yes. Now, to do that by scour would be full of danger, I think. It might wreck the South Pass and split it wide open. It could no more be done, owing to the condition of the banks as they exist there to-day, than you could bore a 4-inch hole through a plank 3 inches wide. It seems to me beyond the range of safe possibility to make such an increase of width and other dimensions in that channel without wrecking it absolutely.

Mr. CATCHINGS. Well, could that be done by dredging, Major?

The WITNESS. That is the only way it could be safely done—by dredging and protecting the banks—and if it were done this way the enlarged dimensions would not be maintained by the present discharge of the pass.

Examined by Colonel GILLESPIE:

Q. Do you subscribe to the doctrine expressed by Mr. Donovan, that the banks in the South Pass receive now all the water they can hold to advantage?—A. I tried to be very careful about that statement. I think it would have been safe to have continued the discharge of 10 or 11 per cent of the water through that channel, but whether that could be restored from 7 to 10 or 11 per cent without danger to the banks I think is doubtful.

Q. No; but the question I asked was, does the South Pass to-day receive all the water that its banks are able to hold?—A. It is bank-full to-day, I consider; yes, sir.

Q. It is bank full to-day and has all that it can hold advantageously?—A. Yes, sir.

Q. Then how could it have been said that the crevasse through Pass a Loutre injures the South Pass to-day?—A. I think the reduction of the discharge—the proportionate discharge through South Pass—is connected with the Pass a Loutre Crevasse.

Q. No, that is not what I mean. If South Pass receives all the water that it can hold advantageously, how can it be said——— —A. South Pass has not the capacity to-day that it has had. When it had a discharge of 10 or 11 per cent, its dimensions were proportioned to this discharge, and had only to be maintained. As the proportion of discharge was lost, the dimensions were reduced, becoming adjusted to the smaller discharge. Now, if the former discharge were restored, the dimensions would require enlargement. This might take place vertically or laterally; hence the danger to the banks.

Q. That is true, but if to-day it holds all the water it can hold advantageously, how can it be said that the crevasse in Pass a Loutre, which abstracted 4 per cent, has dangerously injured that channel?—A. Well, I think the condition is this: The damage to the Pass is continuing. I do not consider it has reached the end of the process. The discharge has been reduced from 10 or 11 per cent to 7 per cent and the Pass has been contracted; that it will remain at 7 per cent, from this time on under the conditions I do not believe. It will continue to decrease, and it is possible that South Pass may eventually become extinct.

Mr. CATCHINGS. Do I understand you to say, then, Major, in answer to Colonel Gillespie, that the reason South Pass to-day has all the water it can carry is because it has become deteriorated partly from the break in Pass a Loutre?—A. I think some of the deterioration of South Pass is due to the break in Pass a Loutre. It started with the loss of some of the work at the Head of the Passes, and, since the Pass a Loutre Crevasse has gone on at an accelerated rate.

Examined by Mr. GALLINGER:

Q. If that crevasse is closed and you turn more water into the South Pass as a result, what then?—A. You might enlarge the channel; you might overflow the banks. Whether the banks or bed would yield most readily to the restored discharge is doubtful. Precaution would have to be used. The water is running over at one place to-day. That would have to be guarded. If it should run over at other places they would have to be guarded also. It would have to be done with care.

Q. It seems to me, Major, that your contention is a little contradictory. A moment ago you said you could not increase the flow with safety, and now you say it could be done; that by closing the crevasse it could be done with safety, in your judgment; a moment ago you said it could not, because it would erode the banks.—A. I think it would erode the banks. I think it is a doubtful question which would erode, the bed or the banks.

Q. It is an experimental matter, then?—A. Yes. I think the best results would have been obtained had the normal discharge been maintained up to the present time. The same discharge which has previously been carried between banks would now overflow them, because the channel has been contracted by the loss of discharge.

Mr. CATCHINGS. Assuming that the crevasse in Pass a Loutre has had a detrimental effect upon the capacity of the Pass to carry off water and that crevasse should be left open, would you think that the deterioration which you say has already occurred would be progressive and farther deplete the channel?—A. As far as I know, the enlargement of the Pass a Loutre Crevasse and the contraction of the South Pass are progressive to-day, and I expect them to continue.

Mr. CATCHINGS. I mean to say, do you think the damage in the South Pass would be progressive, as a result of that?—A. Yes; I think the continuance of the Pass a Loutre crevasse is a detriment to the other two Passes, and I think its enlargement is continuing to-day. The improvement of the Southwest Pass I believe is absolutely practicable, and I think it will meet the demands of commerce, without doubt or special difficulty.

Mr. GALLINGER. Did you hear Major Quinn's testimony in reference to the opening of Southwest Pass, Major?

A. Yes, sir.

Mr. GALLINGER. Do you not agree with Major Quinn in his conclusions?

A. No, sir. South Pass having been improved (with the percentage of water that belongs to it, 10 per cent) to 30 feet and I believe, with the percentage of water that belongs to Southwest Pass (40 per cent and upward), that a channel of 35 feet can be quite as readily and certainly made there. Assuming the Mississippi River to have, at high water, a discharge at the Head of the Passes of about 750,000 cubic feet per second. Of this, Pass a Loutre takes about one-half and the South and Southwest passes, respectively, about 75,000 and 300,000 cubic feet per second. If all the discharge of South Pass flowed through the legal jetty channel, it would have a mean velocity of a little less than 6 feet per second. If the discharge of Southwest Pass, 300,000 cubic feet per second, were passed through a channel of ample dimensions for any ships or any commerce in sight to-day, or of the dimensions I have already described, it would require a mean velocity of over 10½ feet per second. Of course, such a velocity would be destructive and inadmissible, but I draw the comparison only to show the excess of energy at the command of the engineer in developing a sufficient channel through the Southwest Pass jetties.

Examined by Mr. NELSON:

Q. What would you think, Major, of keeping open a deep canal, with a good, substantial entrance lock of the best quality, from the Mississippi, a short distance below New Orleans, down south into Barataria Bay? What would you think of the feasibility and desirability of such an improvement—I mean a suitable canal for all classes of vessels, deep water to the Gulf?—A. There was a plan made for such a canal having a capacity sufficient for the ships of a number of years ago. I do not know of any place where a canal, with the increased capacity that is required to-day, could possibly be made. Breton Island Sound, the outer harbor for the canal proposed in the seventies has entirely insufficient depth for the ships of to-day. The Barataria Canal would have a 6-foot bar at its sea end, which could only be crossed by jetties. I think that nothing but a free and open mouth of the river to the Gulf would ever be at all satisfactory.

Q. What is the distance from New Orleans to the Head of the Passes?—A. A hundred miles.

Q. And from there to the mouth of the South Pass about 12 miles farther?—A. Yes, sir.

Q. And to the mouth of the Southwest Pass, about 18 miles?—A. I think so; or about 16 miles.

Q. Now, you are familiar with the country down there. What would be the shortest distance at which you could obtain a suitable canal? Running out somewhere near English Bend, say.—A. From English Turn?

Q. Yes.—A. I never heard that place spoken of as a location for a canal.

Q. Where was the place spoken of as the location for the canal? How far below New Orleans?—A. I should think 65 or 70 miles. Just below Fort St. Philip. I do not know what the length of the canal would be. The Fort St. Philip Canal was to be 8 miles long, connecting with a 30-foot pocket, which was shut off from the open sea by a bar about 5 miles long with a 25-foot crest.

Q. Well, if you could get a canal of suitable depth, with a lock, do you not think that that would afford a safer and surer channel and give you a better harbor than a channel through the river with its ever-shifting conditions?—A. No, sir. We are willing to trust the jetty system for the improvement of the mouth of this river, absolutely. As I said before, I do not know of any location for a canal that would answer the needs of commerce to-day, leading to 35 feet and upward of water, without jetties.

Q. I would like to ask you, Major, what your opportunities for observation and study of the Southwest Pass have been, as compared with Major Quinn's?—A. His opportunities have been far superior to mine, sir. That has been his business; it has not been mine, you know.

Examined by Mr. BERRY:

Q. I would like to ask you, Major, if you have fixed in your mind any estimate of the probable cost of improving the Southwest Pass.—A. No, sir; I have had no occasion to do so.

Q. And you could give no definite idea as to that?—A. I could not give an opinion that I think would be of any value at all to you. I would like to say (relatively) that I should not suppose it would cost more than the improvements and precautions that I think would be necessary in South Pass. I have no information beyond that which I could give you, and that is merely a speculation.

(The witness subsequently submitted the following statement and

blue print, which were marked, respectively, "Exhibit HH" and "Exhibit II."

EXHIBIT HH.

NEW ORLEANS, *February 14, 1896.*

To the Subcommittee on the Mississippi River of the Committee on Commerce, United States Senate, Senator Knute Nelson, Chairman:

The contract between the United States Government and James B. Eads calls for the following channel depths and widths:

From deep water in the river above the Head of the Passes into and through South Pass, 26 feet of depth, of a navigable width.

Through the jetties, 200 feet wide and 26 feet deep, with a central depth of 30 feet.

Over the bar, at the sea end of the jetties to deep water, 200 feet wide and 26 feet deep, with a central depth of 30 feet.

These channel dimensions were sufficient for the fleets of commerce of 1875, composed of vessels rarely exceeding 300 feet in length and 25 feet in draft.

At the present day many ships are built 600 feet long, with a draft of 30 feet, and it is certain that these dimensions will be materially exceeded in the near future.

We assume that it is the intention of the Government to open the mouth of the Mississippi River to every ship in the world that seeks it on a peaceful errand.

We submit that the minimum channel dimensions now necessary to afford this facility to commerce are as follows:

From deep water in the river into the selected pass, a depth of 32 feet, 500 feet wide, within which width an intermediate depth greater than 32 feet would be developed. These dimensions should be carried through the pass and jetties to a point where the swell of the sea is felt, and from this point the depth of 32 feet, 500 feet wide, should be gradually increased to 35 feet, with the same width, at and over the bar at the sea end of the jetties, with such greater intermediate depths as would be developed. These dimensions should be secured at all stages of the tide and river.

We are of opinion that it would not be practicable, and, if practicable, would not be economical, to enlarge the South Pass and jetty channel sufficiently to obtain these dimensions. The difficulties would be both in securing the enlargement of the waterway and in preserving the integrity of its banks.

We submit with this communication a diagram showing the relative sizes of the channel as now required by law, through South Pass, and of such a channel as is required by the commerce of the present day.

It will be observed that the cross-sectional enlargement called for requires the removal of 557 cubic yards per linear foot, or 34,000,000 cubic yards for the entire length of 12 miles of South Pass. An increased width of channel at the head of the pass and between the jetties would also be necessary, involving the practical reconstruction of these works at both its ends.

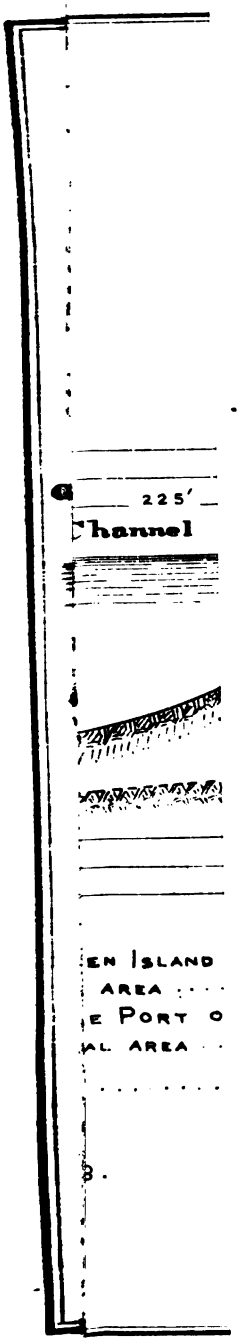
The removal of such an enormous mass of material as above indicated from the channel of South Pass, by whatever means accomplished, would, of itself, plainly involve large expenditures of money, and probably require a greater length of time than other parts of the work of improvement; while the necessary reconstruction, or at least remodeling, of the jetties and other works at its head and mouth must form a large share of the cost of any plan for its further improvement.

To sufficiently increase the navigable depth of South Pass without at the same time unduly increasing its width at the expense of its existing natural banks appears to us a difficult and doubtful undertaking. That it could be so done as to secure an adequate channel for the commerce of the near future without extensive and costly works for the revetment of the banks, so as to prevent their being generally cut back into ground too low to retain the water in the pass, or in some places breached altogether, is at least a matter of grave doubt, although of vital importance.

Moreover, it is by no means certain that the work of improvement could be carried on without greatly obstructing the navigation of the pass during its progress.

We are of opinion that such an outlet as the commerce of the Mississippi River and its tributaries now demands can be most surely and economically obtained by the improvement of the Southwest Pass by means of jetties. The requisite width, depth, and proportion of discharge already exists into and through that pass, excepting the 30-foot shoal in the Mississippi River between Cubits Gap at the Head of the Passes. This obstruction is common to all passes, and must be removed, whichever one is selected for improvement.

The velocity of flow in a stream varies directly as the square root of the product of its hydraulic radius (or the ratio between the sectional area of the part of the bed it occupies and the frictional or resisting surfaces bounding it) by its slope (or the ratio between its fall and length). As the excess of the hydraulic radius of the Southwest Pass over that of South Pass is greater than the excess of the slope in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South Pass over that of Southwest Pass, and as the scouring power increases with the depth and volume, it is reasonable to expect that the greater volume flowing through Southwest Pass will, notwithstanding its lesser slope, give it a velocity and scouring power at least as great as that of South Pass. How much greater can only be determined by survey.

We have had neither occasion nor opportunity to make an estimate of the cost of the improvement of Southwest Pass. Undoubtedly it would be considerable, but not disproportionate to the object in view.

We believe, however, that many of the predictions as to the first cost and the difficulty of maintenance have been exaggerated. It is of record that the increased rate of advance of the South Pass Bar, which was anticipated as the result of the building of jetties, both by the opponents and advocates of the project, has not been realized. On the contrary, it has been retarded rather than accelerated. The natural annual extension of the South Pass Bar seaward was about 100 feet per year before 1875. General Humphreys, then Chief of Engineers, predicted that this rate of advance would be, by the building of jetties, increased to 670 feet per year. (Report of Chief of Engineers, 1874, p. 867.) General Newton, a member of the "Board of Engineers on the improvement of the Passes as an alternative to, or in connection with, the Fort St. Philip Canal," which reported adversely to jetties, estimated the annual advance of South Pass Bar, after the construction of jetties, at probably 2,240 feet, or at least 1,500 feet (pp. 884–885 of same report).

The Board of Engineers which advised the improvement of the South Pass Bar by jetties, composed of three United States engineers, three civil engineers, and one member of the Coast Survey, were of the opinion that: "In an average of many years the rate of progress must be about the same as now, namely, 100 feet per annum." But they assumed that the jetties would have to be extended 1,000 feet in ten years. (Report of Chief of Engineers, 1875, p. 954.)

It is needless to say that neither the apprehensions of the increased rate of bar growth or the necessity of jetty extension has been realized.

We append the average rate of seaward extension of the South Pass Bar since the completion of jetties for every curve of depth from 20 feet to 100 feet, and for the nineteen years from 1876 to 1895. It will be remembered that the growth before the jetties were built was 100 feet per annum.

[Report of Chief of Engineers, 1896, Appendix Q, plate 1.]

Depth of curve.	Advancement per year.	Depth of curve.	Advancement per year.	Depth of curve.	Advancement per year.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
20	33	50	58	80	83
30	34	60	86	90	89
40	48	70	68	100	86

It will be seen from these figures that the average annual advance of the bar has been only about 65 feet, or less than two-thirds the previous rate, and that the curves for 20 feet, 30 feet, and 40 feet depths, with which navigation is immediately concerned, have only advanced, on an average, 45 feet per annum, or less than half the general advance of the bar before the construction of the jetties.

It was observed that the building of the jetties at the Sulina mouth of the Danube delta retarded instead of accelerating the growth of the bar at its mouth. Sir Charles Hartley, the engineer of the improvement, attributed this to conditions which also prevail to a greater or less extent at the mouth of the South and Southwest Passes of the Mississippi. Under these circumstances, there is no reasonable foundation for apprehensions of an excessive or extraordinary increase in the annual rate of extension of the Southwest Pass bar when improved, or of the jetties which should be built across it.

Respectfully submitted.

B. M. HARROD, C. E.,
Member Mississippi River Commission.

HENRY B. RICHARDSON,
Chief State Engineer, Louisiana.

STEAMSHIP WHITNEY (MORGAN LINE),
Below New Orleans, La., February 9, 1898.

A. K. MILLER, sworn, testified as follows:

Mr. Chairman and gentlemen: The subject of these Passes has been so thoroughly discussed in all its bearings by abler men than myself that very little remains to be said.

I would not undertake to set up my judgment against gentlemen of engineering experience. I have listened very attentively to the statements of these gentlemen, and the only point upon which I beg to differ with them is in regard to a subject that I think I am quite familiar with. As a seaman and navigator, and having an acquaintance with the Passes of the Mississippi dating back nearly half a century (forty-nine years), from boy to man, as a commander of ships I have sailed in and out of Southwest Pass and Pass a Loutre on quite a number of voyages. I have now been engaged as a steamship agent in New Orleans for nearly twenty-seven years. I have handled a great deal of tonnage, and I have become fully awake to the necessity of everything that has been asked for to-day upon the part of the committee or its representatives (referring to the committee from the city of New Orleans). I was very much interested in Mr. Donovan's straightforward and comprehensive exposé of the situation and his prompt answers to every question. But he made a statement in regard to the trim of ships that I would like to say a word upon. I have never heard or known of my individual knowledge of any shipmaster or steamship agent loading a ship at the head. It may have been done in some instances where ships were drawing considerably less water than there was in the channel, but I do not know of my own knowledge of any case. In sailing a ship through these Passes, whichever Pass might be selected as fit, it is necessary to prepare against the contingency of grounding.

I also differ with Major Quinn in regard to the depth a ship can be loaded with a certain depth of channel. The depth to which a ship can be loaded with a given depth of water in the channel depends entirely upon the size (length and breadth) of the ship and its draft. While a ship 300 feet long, 35 feet deep, drawing, we will say, 24 feet of water, may readily pass through a channel with 1 foot under her keel, a ship 450 feet long, with fifty-odd feet beam, requires more water than that under her bottom or she will not stay up. A ship of that size, especially with a swift current behind her, to use a nautical expression, "smells the bottom," and she will not answer her helm; she is liable to take a sheer in spite of the best of skill and seamanship in the handling of the ship; and if a ship of that length takes a sheer and swings athwarthorse the channel, for a certain length of time the channel would be blocked. I have myself been a sufferer within the last few weeks. A ship got athwarthorse the channel and my steamer was delayed four days, unable to get to sea in consequence of the channel being blocked and preventing her from passing by. With a swift current, in a high stage of this river, even if there is ample room astern or ahead of a steamship lying across at an angle, it is dangerous to undertake to pass her, for a collision is almost inevitable. I heard it remarked to-day that, no matter how long the ship was, if there was a depth of water and a width of a couple of hundred feet, she could easily navigate. I will admit that may be so in smooth water, but it is very dangerous to trifle with a ship in a strong current, especially where there are eddies. In smooth water many things can be done with a ship. But the increased size of ships

visiting our port requires more water in proportion under the keel; otherwise they are unmanageable.

When I first went into this business, steamships carrying 5,000 bales of cotton were considered good-sized ships. To-day we are loading them with nearly 30,000 bales. As Mr. Sanders ably remarked, we are unable to load our ships with grain with the present condition of the channel. Even if Southwest Pass was no wider and no deeper than the South Pass is to-day, we would require the two passes for the increasing volume of trade at this port, if for no other reason to avoid the possibility of collision, so we could have one pass for ingress and the other for egress. Collisions occur in the largest and best harbors of the world. How much more reasonable is it to presume that they are liable to occur in such a narrow passageway as we have here? And, of course, a ship requires considerable room for turning, in case of necessity. She requires a great deal more than her length, for she must have something to pull and haul upon, and the present channel or passage to the sea is totally inadequate to our present requirements. Captain Donovan very justly remarked to-day, in his observations, that such a case recently happened to a steamship—that never came under his observation before. Why? Because it is only within the last two or three years that we have had such steamships as we have to-day. That is the reason it occurred—because of the unusual length.

Examined by Colonel GILLESPIE:

Q. Is there any limiting speed in the South Pass?—A. I have not been familiar with the requirements of Captain Eads or his representatives or the estate. He has sole control of that pass, but it has never been made known to me that there has been any prohibition with regard to speed.

Mr. SANDERS. There is an order, I believe, of the Secretary of War, limiting vessels to half speed.

Q. There being a limited speed, I should like to have you explain how it is possible for you to block a channel with 1 foot under your keel?—A. If we stopped the ship altogether, she would very quickly lose her steerageway and take a sheer or go, as we say, "athwarthorse," across the channel. A certain amount of speed, commensurate with the size of the ship, is necessary in order to effect a steerageway.

Q. The object of my inquiry was to ascertain what depth under the keel shipmasters think they ought to have in order to have good steerageway, with a modern ship?—A. That depends upon their size, beam, and the construction of the ship.

Q. Well, taking the most modern construction and the longest vessels, how much water under her keel do you think you need in order to have good control over the vessel in passing through this jetty channel at half speed?—A. Two feet, at least. Of course men sailing ships will often do what men will do in other branches of business; in their anxiety to make time, to get to sea, they will sometimes take risks with much less water under the keel. But for prudence sake, and especially if there is a strong current—less would do where there is not a strong current; you could get along with less in perfectly still water—but with a strong current following you, you ought to keep up a certain amount of speed to keep your steerageway; if you lose that steerageway and the current catches you, you are liable to take a sheer.

Q. What is the greatest known draft of any vessel that has ever passed to the sea through South Pass?—A. I think I have the honor of sending the biggist ship to sea that ever went through South Pass.

She had a draft of 27 feet 3 inches. She was a ship that came in here seeking freight. But I may as well state, Colonel, that it makes quite a difference as to the model of ships. This was a sharp ship. A sharp ship will often pass through where these modern ships, which are as flat as this table, very great beam, and what we call a dead flat—unless such ships have sufficient to buoy them they suck the bottom, especially those that are built in these days without a keel. A ship that is built without a keel is very much more liable to lose her steerageway than one with a keel. Very few ships now are built with any keel whatever. They are as flat as this table. Where the keel originally was there is a heavy plate.

Q. Do I understand you to say that, as a representative of the ship interests of New Orleans, you think the Government ought not only to open Southwest Pass but to keep South Pass open?—A. I think we ought to have both.

Q. One for ingress and the other for egress?—A. Yes, sir; the majority of ships entering the port come with ballast. Our import trade has fallen off greatly; it is nothing to what it was before the war.

Q. Do the business interests of New Orleans generally hold to that view, that the Government ought to open both these passes?—A. I have so heard it remarked. Time is very valuable in these days of steam. Much more rapid transit and increased trade could be accomplished with the two Passes.

Mr. BERRY. The import trade has fallen off largely?

The WITNESS. Yes, sir; since the war. Before the war the import trade was very much heavier than it is to-day.

Mr. BERRY. Do you not think that if we had free trade your import trade would largely increase?

The WITNESS. Well, I am not politician enough to determine that matter.

Mr. NELSON. And might not the free coinage of silver also help some?

Mr. BERRY. I know it would; there is no doubt about that.

Q. Suppose Southwest Pass were improved to the extent you advocate now, would you advocate also the maintenance of the South Pass to its present capacity?—A. I think we should find Southwest Pass sufficient for our purposes, but it would be of considerable advantage if we could use the other, too, as long as it lasts.

Q. Could the necessities of the port be met by the maintenance of the Southwest Pass only?—A. Southwest Pass would answer our purpose fully.

Mr. NELSON. If completely improved?

The WITNESS. Yes, sir.

STEAMSHIP WHITNEY (MORGAN LINE),
Below New Orleans, La., February 9, 1898.

T. J. WOODWARD, sworn, testified as follows:

The WITNESS. I have been conversant with the Passes since 1851. I have been detained, while navigating, a great many times on the bar, years ago, before the war. I have given a great deal of thought and attention to the troubles that existed and that now exist down there, and since I left the sea, in 1867, I have been in touch with most all of the people that have been connected or associated with the improvements, from the time of Mr. Eads down. I have been down in the Passes

with almost every commission that has visited the bar and the Passes to make examinations. I had charge of the Congressional committee when Hon. Ben. Butterworth was here, and I went down with the naval commission when they went down there to examine matters with a view to fortifications, and I have been down through there with the Western Waterways Commission, and I have been down there a great many other times. It has been long apparent to me, as it has to all of our shipping men, that South Pass, while not the best Pass to have built the jetties in, has well fulfilled the purpose for which it was improved. But with the advance of commerce, with the increased tonnage, it long ago became apparent that South Pass was not adequate to the commerce of the great Mississippi. And we believe—living in the lower delta, we feel that we are held responsible if we neglect the opportunity to keep the Western people well advised in regard to the conditions of the Lower Mississippi River whenever we have the opportunity. That was our object in going to Washington last winter, and that was our object in going up here in January last; we went up there to see about closing the Pass a Loutre crevasse. We know that that has caused a filling at the Head of the Passes.

It is becoming more apparent all the time that the Government has got to take a hand with the jetty people in order to take care of the filling at the Head of the Passes. The shipping, I know, and we know pretty well, has had no trouble at the lower end of the jetties. The filling at the Head of the Passes, and the sand drifts which have accumulated there since the crevasse has been through there, has been causing a good deal of trouble. And there is trouble there now with this bank which we sounded across this morning, which shows very clearly that there has a filling taken place there, which Major Quinn admits, and which we have shown you on the chart does exist there And I think it is apparent to you gentlemen who have visited the Passes to-day and seen the difference between South Pass and Southwest Pass that Southwest Pass does offer advantages which can not be denied over South Pass. And we do not think, living here in the lower delta, but what the engineering skill which this country possesses can overcome all the difficulties and give us all the water we want through Southwest Pass. South Pass is contracted; it is not wide enough to accommodate the increase in commerce; and, as you have seen to-day, the water is washing over South Pass. I very clearly saw, and pointed out, to-day, that water is flowing over the banks of South Pass already. Southwest Pass has the width, has the natural depth, and is the natural outlet of the Mississippi River, and always has been since I first entered the Passes. And it is a well-known fact that Mr. Eads was not permitted to go into Southwest Pass to erect the jetties because it was feared that he would incommode commerce and would dam up the only outlet which we had to the sea at that time. The canal project was considered a great one at the time the Eads jetties were commenced, and in the Chamber of Commerce of New Orleans, when that thing was proposed, there was but one voice in the chamber that supported Mr. Eads in his project over the canal project from Fort St. Philip out into the East Bay.

Mr. NELSON. Oh, the proposed canal was to be below the fort?

The WITNESS. Yes sir, in the bend; to go out into East Bay. It would have required an immense amount of dredging after the canal had been cut through to get out by Breton Island. And perhaps it is just as well that the canal was never constructed.

In regard to the heavy draft ships and the manipulation of them

through the Passes, you have been pretty well posted, I think. But we must be alive down here to to the necessity of a great outlet to the sea. The products of the West are becoming greater every year. And you heard it pretty well ventilated in Washington by ex-Governor Francis, who gave a most concise statement of the needs of the West and cautioned us that we must look well to our laurels. Take Pensacola, take Mobile, take Galveston, take Sabine Pass—we have got a great deal to contend with here, and unless we do look after this matter in regard to deep water the Mississippi River is going to be very badly left. The fact of the railroads being constructed to Galveston every year is taking away what should come to New Orleans, and Sabine Pass has taken away her portion of it; so unless we are up and alive, we will wake up to the fact that the trade of New Orleans is going to be taken away from us.

In regard to the imports, there is no doubt in my mind but what the imports may increase here; and, with the deep water which Southwest Pass can give us, a natural outlet, I vouch that New Orleans will have a great future.

Mr. SANDERS. Mr. Chairman, on behalf of the New Orleans and Western people who have indorsed our petitions, I wish to tender you our most sincere thanks for the most close and searching inquiry you have given this matter, and for the great patience with which you have listened to all the evidence which has been brought before you. I have but one or two words to say in closing.

I want to point out just one little matter as an evidence of the way the farmer is robbed; for, after all, the farmer pays the piper right straight through from his fields to the markets of Europe for everything that obstructs the carrying of his produce. Last year we had an accident at the mouth of the present jetties (which was alluded to by Mr. Ross). The steamer *Barbara* grounded in that Pass, and it cost $100,000 to get her off and safely to sea again, carrying her cargo of grain from the West to Europe. I was in London in the summer and had occasion to meet the largest underwriters in the world there, and I found that they were chock full of this *Barbara* case, and chock full of the constant groundings in the Mississippi River. They said that they were going to make us pay for it, and they have been as good as their word. They have not made the New Orleans people pay for it, but they are making the produce of the West that seeks its way through the Gulf to Europe pay for it in this way: They have already (at the beginning of this season) advanced our insurance rates per cargo from New Orleans to Europe. They have not advanced the rates from Eastern ports at all, but they have advanced our rates on cotton anyway from an eighth to a quarter of 1 per cent premium.

Now, if we take it at the least computation, one-eighth per cent advance in insurance that they are obtaining and insisting upon, on cargoes out of New Orleans, they are making us pay on cotton this year (largely because of that accident, and entirely because of that accident and other groundings in the past) over $94,000, in the extra rate—in the item of increased insurance—in this one season. And it will be many years before that is reduced. We have been struggling for years to overcome the effect of accidents that used to occur in the Florida channel before the Government properly lighted that channel. Although that channel has been one of the best lighted channels in the world for fifteen years past, we are to-day, in the products going through the Gulf ports, suffering from the effects of wrecks previously piled along

that coast. And it is a very serious thing to allow such prejudices as this to obtain.

I want to remove any prejudice that may have entered your minds from some of the remarks of Mr. Woodward. We have no prejudice against any other port in the United States. We want all ports to get deep water; we want all ports to be able to accommodate the very largest tonnage possible. We believe that deep water and cheap ocean transportation is the only sort of protection that the country can give to the farmers. It is by far the best sort of protection. It is the only method whereby the districts of the West, far distant from the seaboard, can successfully compete in the markets of Europe. And for that reason we desire to see all ports obtain deep water—which we ourselves are struggling for. We have no prejudice whatever.

The city of New York is to-day asking you gentlemen for precisely what we must have, because our tonnage and requirements are the same. They are going to Congress with a request for 35 feet of water. And we do not wish to be understood as asking for only 32 feet of water; we need 35 feet to accommodate the ships already trading at our port, and the ships that are being built and on the docks to-day that will want to come to this port. And while New York is to-day asking for 35 feet, we are in precisely the same position and making the same request.

I have only one word further to say, and that is this: We think the evidence has been sufficient to show that we need a better entrance to this river. We only beg you to give the matter your serious attention and to give us no temporary job, no botch job; give us something that will be permanent. Give us not only a depth that commerce demands to-day, but such a depth as will be required ten, fifteen, twenty years in the future, and the results will return one hundredfold every dollar that shall be expended upon the improvement of the mouth of this river.

Mr. MILLER. Mr. Chairman, I would like to supplement the gentleman's remark apropos of the question that was raised a few moments ago in regard to free trade or tariff. Previous to the building of these jetties which enable us to get ships to the sea, as a steamship agent I have received 30 cents per bushel for the transportation of grain from this port to Liverpool. To-day I am glad to get it for 9 cents, or even 8 cents. Ten cents is considered a good rate to-day. The difference, Mr. Chairman, between 30 cents per bushel and 8 or 9 cents is profit to the man who raises the produce by the sweat of his brow.

GREENVILLE, MISS., *February 16, 1898.*

Senator KNUTE NELSON,
Washington, D. C.

MY DEAR SENATOR NELSON: I have not been unmindful of the request which you made of me to furnish you with the details of local expenditures for levees in the district of which I have charge; but I have been so constantly engaged in field work that I have not had time to carry out my promise till now.

I have received a similar request from Captain Newcomer, to furnish information along certain lines for the use of your committee, so the particulars which I now give you will also be sent to him.

I quote from a letter which I wrote to Captain Newcomer last year containing a sketch of levee construction in this district:

Prior to the civil war there are very few records of the history of the levee system of Mississippi. Some fragments of information may be gleaned from Humphreys and Abbot (pp. 152-154, 159-161, 164-167, edition of 1876) and from Mr. Hewson's book on levees, published in 1858 and since reprinted.

The only portion of the State of Mississippi which is protected by levees is the Yazoo Basin. Prior to 1858 the counties of that tract lying immediately upon the Mississippi River, commonly known as "the front counties," bore the whole expense of the levees. Each county had its separate levee board or individual commissioner, as the case might be. There was also a "superior board of levee commissioners," to which was given, in 1854, a general jurisdiction over the levees. This supervision seems to have been little more than nominal.

Under the separate organizations the counties seem to have accomplished a good deal of work, mostly of a temporary and patchwork kind, and they certainly involved themselves deeply, as we find them in 1860 heavily burdened with debts. Bolivar County owed $197,000; Washington County probably about $165,000; Issaquena County about $100,000.*

In 1858 a great step was taken in advance by the formation of a levee district which included the whole Yazoo Basin. A revenue was provided by a land tax of 10 cents an acre for all alluvial lands, whether in the front or back counties. In addition, the front counties, Tunica, Coahoma, Bolivar, Washington, and Issaquena, were authorized to levy a local tax of 25 cents an acre, if they chose. I do not know how great an income was actually collected from these sources, as several of the counties applied a large part of the revenue to the payment of their debts, as they were authorized to do by the law. It was estimated, in advance, that the income of the district would amount to $360,000 a year from the tax of 10 cents alone. For the year ending April 1, 1860, the net revenue was only about $76,000, which was supplemented by a levy of 25 cents an acre from the front counties, which gave a sum of about $492,000. With this amount in cash and the proceeds of bonds, there were placed under contract, the first year, a quantity of work estimated at about $1,250,000. How much of this was completed can not now be definitely ascertained. Work was soon suspended by the war, and the overflows of 1862, 1865, and 1867 swept away much of that which had been constructed.

Subsequently to the war, in 1867 I think, a board of "liquidating levee commissioners" was organized to settle the outstanding obligations, not only of the general levee board of 1858, but also of the several counties. This board gradually paid off the debts which had been incurred by these old organizations, amounting, it is said, to something like $2,000,000. I am not in possession of the exact figures, but will try to obtain them.

The existence of the general board for the whole Yazoo Basin was not continued after the war. There was a division of councils, and after 1865 the levee organizations were separated into two, corresponding, in the main, to what are now the Upper and Lower Yazoo districts.

I shall not recapitulate the history of the latter district, as it is contained in accessible records. This district, since its organization in 1865, has expended up to the 31st of December, 1897, the sum of $8,782,153.58. This amount includes not only actual earthwork, but salaries, rights of way, interest on borrowed money, etc. It does not, of course, contain repayments of borrowed money. It simply represents the net disbursements of all kinds for levee purposes. The quantity of earth put up during this period is approximately 21,000,000 cubic yards (exactly, 20,937,848).

Since the date when the partnership began between the United States and the local authorities in the work of levee building the Lower Yazoo levee district has expended $5,224,235.11. It has put up 14,777,509 cubic yards of earth. The period embraced by this statement is from July 1, 1882, to December 31, 1897. The work done by the United

* Report of the president, engineer in chief, and treasurer of the levee commissioners to the legislature in April, 1860. Vicksburg, 1860.

States Government during the same time can best be obtained from them. Up to July 1, 1896, the sum expended was $1,366,642.36. The yardage of earthwork done up to the same date was 6,706,447. Since that time a very large quantity of work has been done. The allotments of 1896 and 1897 amount to $751,300, which has already mostly been expended, but I do not know exactly how much nor how many yards of earth have been put up.

In answer to the more particular inquiries of Captain Newcomer, I have addressed him a letter containing detailed statements, which will no doubt be forwarded to you. I inclose you a copy of my letter to him on the history of levee construction, from which I have quoted some passages. It may, perhaps, contain something which you would like to know or which might be useful in making up your report.

I shall be happy to furnish any information in my possession at any time.

I am, Senator, very respectfully,

WM. STARLING,
Chief Engineer Mississippi Levee District.

I send also a pamphlet prepared for the last meeting of the Mississippi River Commission in New York, June, 1897. It has been corrected up to December 31, 1897, and contains data which may be of use.

Statement sent to Captain Newcomer February 3, 1897.

SKETCH OF LEVEE CONSTRUCTION IN THE MISSISSIPPI LEVEE DISTRICT.

Previous to the civil war there are very few records of the history of the levee system of Mississippi. Some fragments of information may be gleaned from Humphreys and Abbot, pp. 152–154, 159–161, 164–167, edition of 1876, and from Mr. Hewson's book on levees, published in 1858 and since reprinted by Van Nostrand. The latter work gives considerable information about details of construction at that day.

The only portion of the State of Mississippi which is protected by levees is the Yazoo Basin. Prior to 1858 the counties of that tract lying immediately upon the Mississippi River, commonly known as "the front counties," bore the whole expense of the levees. Each had its separate levee board or individual commissioner, as the case might be. There was also a "superior board of levee commissioners," to which was given, in 1854, a general jurisdiction over the levees. This supervision seems to have been little more than nominal.

Under the separate organizations the counties seem to have accomplished a good deal of work, mostly of a temporary and patchwork kind, and they certainly involved themselves deeply, as we find them in 1860 heavily burdened with debts. Bolivar County owed $197,000, Washington probably about $165,000, Issaquena about $100,000.*

In 1858 a great step was taken in advance by the formation of a levee district which included the whole Yazoo Basin. A revenue was provided by a land tax of 10 cents an acre for all alluvial lands, whether in the front or back counties, it being recognized that the latter participated in the benefit derived from the levees. In addition to the fund thus provided, the front counties, Tunica, Coahoma, Bolivar, Washington, and Issaquena, were authorized to levy a local tax of 25 cents an acre, if they chose. I do not know how great an income was actually collected from these sources, as several of the counties applied a large part of their revenue to the payment of their debts, as they were authorized to do by the law.

It was estimated, in advance, that the income of the district would amount to $360,000 a year from the tax of 10 cents alone. For the year ending April 1, 1860, the net revenue was only about $76,000, which was supplemented by a levy of 25 cents an acre from the front counties, which gave a sum of about $492,000. With this amount in cash and the proceeds of bonds there were placed under contract the first year a quantity of work estimated at about $1,250,000. How much of this was

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*Report of the president, engineer in chief, and treasurer of the levee commissioners to the legislature, to April, 1860. Vicksburg, 1860.

completed can not now be definitely ascertained. Work was soon suspended by the war, and the overflows of 1862, 1865, and 1867 did much damage.

Some of the levees constructed by this board are still in existence. The standard dimensions adopted were, a crown of 5 feet, a front slope of 6 to 1 and a back slope of 2½ to 1. Grades varied from 4 feet in De Soto and Tunica counties and 4.5 in Coahoma to 5 feet in Washington and 5.4 in Issaquena, above the highest water, which was in 1858 or 1859, as the case might be. These grades corresponded, until very recently, to those of our highest levees, and it is only lately that the old embankments are being obliterated under recent enlargements.*

After the war there was a division of councils. The upper counties and the back counties failed to cooperate with the lower river counties of the Yazoo Basin, and the latter organized a levee system of their own, under a board called the commissioners for Bolivar, Washington, and Issaquena counties, in the year 1865. It was not until 1871 that the upper part of the basin undertook to restore and maintain their line of levees. In that year they organized under the name of Levee District No. 1. The district comprised the counties of De Soto, Tunica, Coahoma, Tallahatchie, and Panola, besides six towships of Sunflower. Their revenues were derived from a land tax. They were authorized to borrow $1,000,000.

District No. 1 soon got into financial difficulties, and in 1876 it was formally abolished by law. Their scrip is still seen quoted in the market at 10 cents or so on the dollar.

After the demise of District No. 1, the title of the lower district was changed to the Mississippi Levee District, it being then the only levee organization in the State. This name it still bears in all official proceedings.

In 1884 the counties formerly belonging to District No. 1, and one or two others, were organized as the "Yazoo-Mississippi Delta Levee District," and are now officially known by that name. In common parlance the two districts are known as the upper and lower districts of Mississippi, or Upper and Lower Yazoo districts. The latter is the name by which they are generally designated by the officers of the United States service. To the lower district the county of Sharkey has been added (a new county, made of parts of Washington and Issaquena) and about 12 square miles of the adjoining part of Warren County. The upper district has, in addition to the original counties embraced in the former organization, the new county of Quitman and the counties of Leflore, Yazoo, Holmes, and the rest of Sunflower, or so much of them as is alluvial land.

On the reorganization of the Lower Mississippi district, in 1865, vigorous measures were taken looking to a speedy completion of the system, so far as that district was concerned. The same engineer was in charge as in 1860, Mr. Minor Meriwether A survey was made of the whole line, and a continuous line of levels was run. The map of the survey is still extant, and is the source of all our knowledge of the levees as far back as 1867. All of the old records have disappeared except that. Consequently, the pedigree of our levees can not be traced any further.

The principal source of the revenue of the new organization was the then novel expedient of a cotton tax; that is, an excise or internal tax on that product. In 1865 it was fixed at the rate of 1 cent per pound of net cotton, or about $4 a bale. This produced a large income, but prices of work were very high (often 40, 50, or 60 cents a cubic yard) and the administration was often very lax, for it was the "reconstruction" period. There is, then, very little to show for the large amounts spent from 1865 to 1876.

In 1876 a "reform board" came into power, and devoted itself to rehabilitating the finances of the district, which had fallen into bad plight. So diligently did they exert themselves that they paid off, in the six years of their existence, about half a million dollars of debt, and did a good deal of work besides. Unfortunately, these were all (except 1876) years of low water, and 1876 itself was a second-class flood. Consequently, the people and the board forgot the lessons of 1862 and 1867. Indeed, they actually discredited the records of the former flood, and they have continued to be discredited till they were repeated in 1890. Therefore more attention was paid to economy than to efficient protection. The taxes were reduced to $1 a bale or less, and almost all the money spent in construction was for new levees, made necessary by caving. Very little was expended in enlargement. When the great flood of 1882 came, it wiped out levees and board alike.

The Mississippi River Commission was then just getting into active operation. They had completed lines of precise levels along the whole front of the district. Under the pressure of sympathy with the distress prevailing in the Mississippi Valley a very large appropriation was made by Congress for the Mississippi River, and a liberal construction was placed on the law authorizing allotments for levee purposes. Out of the $4,123,000 appropriated for the Mississippi River Commission, about $1,300,000 were allotted for levees. Of this amount some $364,000 were set

* Humphreys and Abbott, pp. 164–165.

apart to the Lower Yazoo district. The latter organization, in addition to their regular income, borrowed $200,000, and between the General Government and the local board the work of repair and construction proceeded vigorously.

From 1882 may be dated the modern régime of levee building. There was in charge of this district at that time a disciple of Meriwether, Maj. George M. Helm, an ex-Confederate officer, who, carrying out the policy of his former chief, ran a line of levels along his whole front, checked on the Government precise benches, and made accurate estimates and fixed uniform grades and dimensions. From that time to this the history of the levee system here and elsewhere is well known, or can easily be ascertained by authentic and accurate records.

When Major Helm took charge, in 1882, there was no continuous profile of the levee line in existence. If Meriwether made one it could not be found, nor were there data for the numerous changes that had occurred since his day. So the profile made in 1882 (of which you have a copy) is the earliest authentic record of grades, with the exception of the few levees constructed by the board of 1876–1882, commonly called the Ferguson board, from its president. The engineer of this board, Mr. T. S. Anderson, a very competent man, preserved accurate notes of his cross sections and grades. The latter were almost uniformly referred to the high water of 1876. No memoranda are extant, however, of the elevations of the high-water marks of this year, because there were no standards to refer them to. By referring to the gauge records of Helena, White River, and Lake Providence, we may be enabled to compare this flood with 1882 or other standards. There are also old watermarks, preserved by individuals, which have been compared with known data. Thus at Helena the high water of 1876 was 44.85 on the gauge—2.35 less than 1882. At White River Landing it was 1.70 less than 1882. At Arkansas City it was probably about 1.5 less; at Lake Providence, about 0.4 less. At Vicksburg the record is vitiated by the cut off.

The high grades fixed in 1859 and 1860 obtained only in a few cases. Most of the levees then in existence were of inferior height and strength. In 1857 and 1858 Humphreys and Abbot found the average height of the levees of the Yazoo Basin to be only about 4 feet. In 1874, according to the report of Colonel Benyaurd, obtained from local authorities, the average height of the levees of the Lower Yazoo district was about 8 feet, with a crown of 6 feet and side slopes of 4 to 1 and 2 to 1.* It is thought that this is an overestimate, as in 1882 the average height was only about 7 feet, with slopes probably considerably less than those given above.†

The grade established in 1882 by the Mississippi River Commission was the height of the adjoining stretch of old levee, next to the new constructions, provided, however, that the grade should never fall below the high-water line of 1882. Now, the grades of the old levees differed among themselves excessively. Some were old "Meriwether levees," some were 3 feet above 1876, and some were mere temporary or low-grade lines. Consequently the grades of the new levees built in 1882, and also of the enlargements undertaken at that time, were very variable. You will see instances of levees 4 feet higher than the flood mark of 1882. In many cases the water of 1882 ran clean over the levees and broke them. In such cases a liberal interpretation was generally placed on the rule of the commission and a stretch of levee selected as the criterion which was well above the water line. Usually the new constructions were about 2 feet above high water.

The grade was gradually raised to 3 feet above the high water of 1882 till 1886, when a new criterion was furnished in some places. In 1884–85 the Yazoo-Mississippi Delta Levee district, or the Upper Yazoo district, was organized and went to work with great vigor. They immediately closed the entire gap in the Yazoo front, and when 1886 came, although the flood was far less than 1882, it yet reached a greater height at Helena by nearly a foot. There were two or three insignificant breaks in the upper district and none at all in the lower, so that the water line was far less disturbed than in 1882. It was also often higher in the vicinity of the breaks of 1882, which had had a local influence in depressing the water line of that year. Wherever the flood of 1886 was the higher it was adopted instead of 1882 as the standard.

In 1887 the closure of the Arkansas levees was effected. This again had a very serious influence on the flood line below the Arkansas River, or rather Cypress Creek, the head of the Tensas levee system. In the next year, 1888, there occurred a flood which, at Cairo and Helena, was a very moderate one. At the former point it was 6.6 feet below 1882, and at the latter 4.4 below. At Arkansas City, however, it was only 1.8 below 1882, at Greenville 1.1 below, and at Lake Providence only 0.2 below. There were no crevasses anywhere.

It was thought, from this latter circumstance, that there was thus presented a

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* Report of the Commission of Engineers in 1874, commonly called the "Warren Board," Chief of Engineers for 1875–76, part 1, p. 597.

† Report of G. M. Helm in Report of Mississippi River Commission for 1883, p. 2858.

favorable opportunity for establishing a uniform grade line below the inclosed reach—that is, from Cypress Creek down. Consequently, 5 feet above the high water of 1888 was adopted as the grade of all the levees of the Lower Yazoo district below Mound Landing, which is about opposite a point three miles or so above Arkansas City. Above this point 1882 or 1886, as the case might be, was still maintained as the standard.

It was not possible at that time to build our levees of full dimensions to this grade, so they were constructed with crowns of only 2 feet, as you will frequently see noted in the list given you. It was soon perceived that this width of crown was altogether insufficient. It left no room to handle men or store materials during high water; it left no margin for the wash of waves during storms, and afforded no opportunity for "topping" in case of deficient grades or excessive local engorgements during floods. So the very next year a loan was negotiated and means found to bring the 2-foot crowns to 8 feet.

The flood of 1890 furnished a new criterion for grades by utterly abolishing all previous records along the Lower Yazoo front, except a few scattered and poorly authenticated watermarks of 1862. While 1890 was a very prolonged flood at Cairo and Helena, it was not so very high. What made it so formidable below was the unprecedented stage in the Arkansas and White rivers, particularly the latter, which stood at a height not far below extreme flood for four months. Even for a considerable distance above the mouth of these two streams the water line felt the influence of the outpour from them. While at Helena the mark reached in 1890 was half a foot above 1882, or 0.4 below 1886, at the upper end of this district it was 2 feet above 1882, or 1.5 above 1886, and at the lower end of the district it was from 2.5 to 3.5 above either, or above any other mark except 1862. So far as the very imperfect and doubtful records of the latter year afford the opportunity for comparison, the two floods attained about the same height along the Providence Reach. At Vicksburg 1862 was altogether the higher, but here again the cut-off of 1876 has interfered to prevent the comparison.

As there were numerous and very great crevasses on both sides of the river in 1890 it was thought that it did not afford at all a correct criterion for a grade line. I therefore undertook to find out what the water line would have been had there been no breaks. I found that the river was rising at a tolerably uniform rate when the first break occurred and that at points above the influence of the breaks it continued to rise pretty steadily after they had happened. I therefore reasoned that by prolonging the rate of rise at each place before the breaks until the time when, by calculation, the flood would have culminated, an approximation could be obtained of the flood height which would have prevailed had no crevasses taken place. Thus I constructed what I called a "potential high-water line" and used it as a basis for a grade. In 1890 new levees were built to this grade throughout the district.

In 1891 a flood occurred which was not so great by any means as 1890, but which was much better confined. Only two breaks occurred between White River and Vicksburg, and one of those was insignificant. Therefore the flood line of this year was adopted as a basis for a grade line below Mound Landing, the standard being 4 feet above the high water of that year. Above Mound Landing 1 foot above the "potential high-water line" of 1890 was still used, until it was superseded by the ordinary grade of so many feet above the highest water. This latter was adopted by the officers of the Government, and for convenience I have conformed to it. Wherever, in the lists furnished you, levees have been built to the hypothetical grade mentioned I have reduced it to actual high water.

The floods of 1892 and 1893 have also been signalized by heavy outpours from the White and Arkansas rivers, especially in 1892. They have therefore produced very high water below Cypress Creek and have furnished the standards for late grades below Mound Landing, or rather below Catfish Point. At and below Greenville they have been very nearly the same—sometimes one year having been the higher, sometimes the other, according to local incidents.

WM. STARLING,
Chief Engineer Mississippi Levee District.

CLARKSDALE, MISS., *February 21, 1898.*

Hon. KNUTE NELSON,
United States Senate, Washington, D. C.

MY DEAR SIR: I inclose with this, for the information of your committee, a paper marked A, which is a copy of a statement prepared for and by request of the Mississippi River Commission, "showing yardage

and cost of levees built or to be built by State or local authorities, with funds appropriated or raised, up to December 31, 1897," in the "Upper Yazoo Levee District."

Also a paper marked B (which you have already seen in print), being a "detailed statement of construction and expenditures done by the Upper Yazoo Levee District from May 1, 1884, to June 1, 1895." This, in connection with the first-named paper, is designed to show in what channels and for what purposes the levee board revenues have been expended other than directly for the purpose of levee construction.

I also append to this a statement showing all allotments of money made by the United States Government for levees in this levee district, the earliest expenditure having been made in the year 1883, to wit:

In 1883	*$50,000.00
Between 1883 and June, 1896	799,304.00
In June, 1896	16,250.00
In June, 1897	71,060.00
For high water of 1897	20,000.00
Total	956,614.00

It will afford me pleasure to furnish any other information on the above or kindred subjects that I may be able to give.

Very respectfully,

T. G. DABNEY,
Chief Engineer Yazoo-Mississippi Delta Levee District.

A.

UPPER YAZOO LEVEE DISTRICT.

Yardage and cost of levees built or to be built by State or local authorities with funds appropriated or raised up to December 31, 1897.

Yardage built to June 30, 1896, 8,019,513.

Expenditures to June 30, 1896: Paid to contractors, $1,658,457.21 (A). Paid for all levee purposes, including (A), $2,767.790.80 (not including sinking fund).

Yardage built June 30, 1896, to December 31, 1897, 2,185,578.

Expenditures June 30, 1896, to December 31, 1897: Paid to contractors, $300,712.84 (*a*). Paid for all levee purposes, including (*a*), $442,696.26 (not including sinking fund).

Available balances December 31, 1897, $301,095.63.

Estimated future cost per yard: 17 cents for this season; 18+ cents for future work.

Probable yardage to be built with available funds: 1,475,000 (now under contract).

Total yardage built and to be built: 11,680,091 (to end of present season).

Total cost of same: Paid and to be paid to contractors, $2,167,420.05 (*a*). Paid for all levee purposes, including (*a*), $3,511,582.69 (not including sinking fund).

B.

Detailed statement of construction and expenditures done by the Upper Yazoo levee district from May 1, 1884, to June 1, 1895.

Construction (7,124,615 cubic yards)	$1,564,376.17
Bank protection	42,653.77
Drainage (canals, culverts, siphons, etc.)	14,985.29
Right of way and damages	82,102.78
High-water expenses	62,505.84
Levee maintenance	70,344.29
Telephone construction	2,206.59
Engineering expenses	129,032.98
Salaries (president, secretary, treasurer, auditor) and mileage and per diem of members of levee board	47,476.19

*Approximate.

Attorneys' fees	$9,513.03
General expenses (miscellaneous)	29,476.93
Express, exchange, and commissions on sale of bonds	21,074.34
Interest and coupons	555,882.17
Sinking fund	175,000.00
	2,806,630.37
Less sinking fund	175,000.00
Total	2,631,630.37

GREENVILLE, MISS., *February 12, 189*

To the Honorable the Senate Committee on Floods.

GENTLEMEN: In response to your direction, I below submit my testimony upon the floods of the Mississippi River—their causes, duration, effect, and methods for their control.

Cause.—The primary cause of the floods of the Mississippi River in recent years seems generally agreed upon as being improved drainage, with the denudation of the drainage basin of the river and its tributaries of timber, and the increased area of cultivated land. A secondary cause is the contraction of section at flood stage, due to the extensive construction of controlling levees. The first cause has been discussed and elaborated upon by those authorities who have the time and resources to present it in tangible shape. The second cause is a self-evident proposition, to which there is only one important question, viz, to what extent the future increase of the existing length of fully leveed channel will raise the flood heights of coming years? This once determined, it is only a question of dollars and cents as to the ultimate completion of the levee system to a safe grade and the final prevention of damaging overflows, except from backwater going up the mouths of the tributaries.

Owing to the leveeing of the St. Francis Basin, and the consequent restriction of the usual outflow into it, the flood of 1897 at Cairo has been surpassed by only two of record (1882 and 1883), while no flood of record was sustained for such length of time at that point. All construction of levees on the Mississippi River has been based on grades established a certain number of feet above the highest known water. As this height has increased from year to year, the grades have been changed. Where this has been done by local organizations with limited means, the height of the embankment has been in many instances increased without a corresponding addition of cross section.

It has only been since the assistance of the General Government has been enlisted that the present standard section has been used in new construction. Owing to the above mentioned fact and the faulty construction of many sections of levee dating prior to or immediately after the civil war, some of the crevasses which occurred in 1897 were due; but it is an indisputable fact that the levees at the then existing grade were in many instances overtopped by the flood wave and the puny efforts of any body of men that could have been concentrated on the line as then existing could not have prevented the escape of the river at some point from its leveed boundaries.

Remedies.—The experience of 1897 on the levees of the Upper Tensas Basin in Arkansas demonstrates fully that levees constructed by the United States Engineer Corps under the specifications now in use, with slopes of 3 on 1, crown 8 feet, with banquettes gave little or no

trouble, even with the water at the top and in some instances running over. This section is in the crossing of water courses and for extremely high levees increased to as much as a 5 to 1 slope, with a corresponding increase of crown to 12 feet, and given a higher grade.

The safe cross section being established, it only remains to find a safe grade to compute correctly the cost of a levee system from Cairo to the Head of the Passes.

Grade.—To quote from Maj. William Starling's letter to Col. W. L. Gillespie, president of the Mississippi River Commission (dated May 21, 1897), the reasoning and conclusions of which, as applied to the flood of 1897, I believe to be in substance true, the gauge reading would have been (had no crevasses occurred): At Helena, 53.5, 1.6 above actual height recorded; at Arkansas City, 56.0, 4.1 above actual height recorded; at Lake Providence, 49.0, 4.6 above actual height recorded.

This showing that the present grade for work now under construction of 3 feet above high water 1897 is about 1.5 too low for a recurrence of the flood of 1897, if controlled within the levees, or that to allow a moderate factor of safety this grade should be from Helena south 6 feet above high water of 1897.

The magnitude of the undertaking of constructing a levee system to this grade is so great that the local organizations along the river are not possessed of the means, having in many instances for the construction of existing works taxed the property owners to a point that is nearly unbearable, and almost exhausted their credit. From these causes the popular cry for the control of the levees by the General Government proceeds.

The advisability of this step on the part of the Government is from an engineering standpoint very plain to my mind.

A continuous, tangible, well-directed effort toward any given end is better than a desultory one which is hampered by lack of means and concert of action. Coupled with this, economies of construction, resulting from the taking of the work from bodies more or less swayed by politics and local influences, are bound to be immense. The justice of the assumption of this charge by the United States seems, from a general standpoint, to be admitted. The question of the commercial advantage and economy of this step is being presented to your honorable body by those who have compiled statistics from almost every obtainable source.

As regards the section immediately protected by the levees under my charge, the Upper Tensas district in Arkansas, the following statement of conditions as applied to Chicot County affords a fair comparison of the crop values with and without levees. No crevasses occurred in the front levees of this district in 1897, except a small one about 400 feet wide, near the head of the present system.

Chicot County statistics.

Articles.	Value in 1897.	Value in 1892 (overflowed).
Cotton	$1,092,266	$5,350
Cotton seed	61,465	265
Hay	10,809	.....
Potatoes	6,500	.....
Cattle	54,000	.....
Hogs	12,100	.....
Total	1,237,130	5,615

An overplus of $1,231,515.

These figures were furnished by the Chicot County levee board and attested to by R. W. Reynold, special statistician.

With the exception of raising of grade the levee system in the upper Tensas basin district in Arkansas is practically complete to Costellos Gin, the bulk of the work being of standard section (about 71 per cent of the whole having been built by the United States).

There will be needed, as an addition to this, a continuation of the system up the Arkansas River, as follows:

ARKANSAS RIVER LINE.

In 1895 and 1896 Capt. C. McD. Townsend, Corps of Engineers, for the United States, constructed 12.4 miles of levee of standard section from Red Fork, on the south bank of the Arkansas River, down that river.

The Mississippi River levees begin at Costello's Gin, this point being about 8 miles from the terminus of the Government levee on Arkansas River. Both of these lines are shown on a map which is sent herewith, together with dotted lines marked "A" and "B" to show proposed new line to complete the system. The necessity for the completion of one or the other of these two lines is clearly shown by the map, and a reference to the discharge through this opening in flood time, which was 120,000 cubic feet per second. This is almost equal to the greatest flood discharge of the Arkansas River during the high water of 1893, which was 196,900 cubic feet per second, the gauge reading being 24 feet at Little Rock.

It seems to me that the choice of lines would be line A, which would require the digging of a canal ditch south of Arkansas City from Fulton Lake to Bayou Macon. This ditch would cost approximately $10,000, and the cost should be defrayed jointly by the united levee boards (Desha, Chicot, and Tensas Basin). Line B, which terminates at a point opposite Cypress Creek, will cut off nearly all the flood water, and, with this protection afforded, the country would in a few years be financially able to continue this line, closing on the present line at or near Opossum Fork levee. The difference in the cost of the two lines suggested will be small. Partial appropriations would satisfy the wishes of the people; say at the rate of about 7 miles each year of line B. The total length of line B is 19 miles; total yardage, 3,746,206, at an estimated cost of 18 cents, would amount to $671,317.08; or 7 miles of this per annum would be 1,218,513 cubic yards, at 18 cents, $219,333.24. In addition to this, new lines will be required from time to time to keep up the system as the river encroaches in caving bends.

Estimating the cost of enlargement for 3 feet above high water, 1897, there is at present needed for main line and extensions:

	Cubic yards.
Main line	1,586,500
Enlargement of Red Fork line	350,000
Arkansas River extension	3,746,206
Total	5,682,706

At an estimated cost of 18 cents=$1,022,887.08.

This amount and an added amount of not exceeding $10 per station per annum for repairs, weed cutting, etc., or $43,600, should cover the present needs of the situation. It is essentially necessary that a regular surveillance of the levees be had even after the completion of the

system to a degree of perfection, and that the levee be kept free of weeds and timber and well sodded with Bermuda grass.

It is extremely important that the present grade of the levee in the vicinity of the junction of Arkansas and White rivers with the Mississippi be raised to a higher grade than now exists—say to 7 feet above the high water of 1897. This increase in height should extend up the river to a point near Australia, Miss., and down the river to a point near Greenville, being gradually diminished below that to the standard grade adopted. This addition in grade should apply to both sides of the river, and is needed to provide for the influx of water from the two rivers mentioned, which has a holding up tendency for some miles above and below.

The immediate proximity on the Mississippi side of the river of a vast body of cultivated land, well settled and productive, with strong local levee organizations to present its claims, where compared with a small strip of cultivated land, sparsely populated and having weak levee organizations, which exist in Arkansas, has led to a popular belief that there is a discrimination on the part of the Mississippi River Commission in the allotment of funds for levee purposes against the Arkansas side of the river.

While I do not coincide with and am not prepared to establish this belief, it is, if true, in a measure unjust, as the immense interests in the lower end of the basin in Louisiana have been overlooked. It is a proposition that can not be combated that no government has a right to injure any citizen for the benefit of others, except upon the ground of the public weal. For this reason, as well as the general scheme of the control of the river, the future construction of levees should be equal in pace on both sides of the river. A crevasse disturbs the general regimen of the river, no matter where it occurs.

It has occurred to me that the flood line would be reduced by increased current if the land were denuded of all trees and undergrowth from the shore line to the levees except a small strip of willows along the levees for protection against wave wash. This would increase the current across the narrow necks and might be the means of causing cut-offs.

As there is no way of forecasting the good or bad effects of this denudation, it seems to me to be well worth mentioning in order to bring out the opinions of others. The presence of timber and undergrowth greatly aids the building up of the surface from the shore line to the levees. This is, of course, done at the expense of a decrease in current.

As I conceive that my testimony before your honorable body should be relative only to the question of feasibility of control of floods and their effects, I have refrained from other evidence.

Respectfully submitted.

E. C. TOLLINGER,
United States Assistant Engineer.

NEW ORLEANS, *February 14, 1898.*

Senator KNUTE NELSON,
Chairman Subcommittee on the Mississippi River of the Committee on Commerce, United States Senate:

The contract between the United States Government and James B. Eads calls for the following channel depths and widths: From deep water in the river above the Head of the Passes into and through South Pass, 26 feet of depth, of a navigable width. Through the jetties, 200

feet wide and 26 feet deep, with a central depth of 30 feet. Over the bar, at the sea end of the jetties, to deep water, 200 feet wide and 26 feet deep, with a central depth of 30 feet.

These channel dimensions were sufficient for the fleets of commerce of 1875, composed of vessels rarely exceeding 300 feet in length and 25 feet in draft.

At the present day many ships are built 600 feet long, with a draft of 30 feet, and it is certain that these dimensions will be materially exceeded in the near future.

We assume that it is the intention of the Government to open the mouth of the Mississippi River to every ship in the world that seeks it on a peaceful errand.

We submit that the minimum channel dimensions now necessary to afford this facility to commerce are as follows:

From deep water in the river into the selected pass, a depth of 32 feet, 500 feet wide, within which width an intermediate depth greater than 32 feet would be developed. These dimensions should be carried through the pass and jetties to a point where the swell of the sea is felt, and from this point the depth of 32 feet, 500 feet wide, should be gradually increased to 35 feet, with the same width, at and over the bar at the sea end of the jetties, with such greater intermediate depths as would be developed. These dimensions should be secured at all stages of the tide and river.

We are of opinion that it would not be practicable, and, if practicable, would not be economical, to enlarge the South Pass and jetty channel sufficiently to obtain these dimensions. The difficulties would be both in securing the enlargement of the waterway and in preserving the integrity of its banks.

We submit with this communication a diagram showing the relative sizes of the channel as now required by law through South Pass, and of such a channel as is required by the commerce of the present day.

It will be observed that the cross sectional enlargement called for requires the removal of 557 cubic yards per linear foot, or 34,000,000 cubic yards for the entire length of 12 miles of South Pass. An increased width of channel at the head of the pass and between the jetties would also be necessary, involving the practical reconstruction of these works at both its ends.

The removal of such an enormous mass of material as above indicated from the channel of South Pass, by whatever means accomplished, would of itself plainly involve large expenditures of money, and probably require a greater length of time than other parts of the work of improvement, while the necessary reconstruction, or at least remodeling, of the jetties and other works at its head and mouth must form a large share of the cost of any plan for its further improvement.

To sufficiently increase the navigable depth of South Pass without at the same time unduly increasing its width at the expense of its existing natural banks appears to us a difficult and doubtful undertaking. That it could be so done as to secure an adequate channel for the commerce of the near future without extensive and costly works for the revetment of the banks, so as to prevent their being generally cut back into ground too low to retain the water in the pass, or in some places breached altogether, is at least a matter of grave doubt, although of vital importance.

Moreover, it is by no means certain that the work of improvement could be carried on without greatly obstructing the navigation of the pass during its progress.

We are of opinion that such an outlet as the commerce of the Mississippi River and its tributaries now demands can be most surely and economically obtained by the improvement of the Southwest Pass by means of jetties. The requisite width, depth, and proportion of discharge already exist into and through that pass, excepting the 30-foot shoal in the Mississippi River between Cubits Gap and the Head of the Passes. This obstruction is common to all places, and must be removed whichever one is selected for improvement.

The velocity of flow in a stream varies directly as the square root of the product of its hydraulic radius (or the ratio between the sectional area of the part of the bed it occupies and the frictional or resisting surfaces bounding it) by its slope (or the ratio between its fall and length). As the excess of the hydraulic radius of the Southwest Pass over that of South Pass is greater than the excess of the slope in South Pass over that of Southwest Pass, and as the scouring power increases with the depth and volume, it is reasonable to expect that the greater volume flowing through Southwest Pass will, notwithstanding its lesser slope, give it a velocity and scouring power at least as great as that of South Pass; how much greater can only be determined by survey.

We have had neither occasion nor opportunity to make an estimate of the cost of the improvement of Southwest Pass. Undoubtedly it would be considerable, but not disproportionate to the object in view.

We believe, however, that many of the predictions as to the first cost and the difficulty of maintenance have been exaggerated. It is of record that the increased rate of advance of the South Pass Bar which was anticipated as the result of the building of jetties, both by the opponents and advocates of the project, has not been realized. On the contrary, it has been retarded rather than accelerated. The natural annual extension of the South Pass Bar seaward was about 100 feet per year before 1875. General Humphreys, then Chief of Engineers, predicted that this rate of advance would be, by the building of jetties, increased to 670 feet per year. (Report Chief of Engineers, 1874, p. 867). General Newton, a member of the "Board of engineers on the improvement of the passes as an alternative to, or in connection with, the Fort St. Philip Canal," which reported adversely to jetties, estimated the annual advance of South Pass Bar, after the construction of jetties, at probably 2,240 feet, or at least 1,500 feet (pp. 884 885 of same report).

The board of engineers which advised the improvement of the South Pass Bar by jetties, composed of three United States engineers, three civil engineers, and one member of the Coast Survey, were of the opinion that "in an average of many years the rate of progress must be about the same as now, namely, 100 feet per annum;" but they assumed that the jetties would have to be extended 1,000 feet in ten years. (Report Chief of Engineers, 1875, p. 954).

It is needless to say that neither the apprehensions of the increased rate of bar growth nor of the necessity of jetty extension have been realized.

We append the average rate of seaward extension of the South Pass Bar since the completion of jetties for every curve of depth from 20 feet to 100 feet, and for the nineteen years from 1876 to 1895. It will be remembered that the growth before the jetties were built was 100 feet per annum.

The curve of 20 feet depth has advanced 33 feet per year; 30 feet depth, 54 feet per year; 40 feet depth, 48 feet per year; 50 feet depth, 58 feet per year; 60 feet depth, 86 feet per year; 70 feet depth, 68 feet per year; 80 feet depth, 83 feet per year; 90 feet depth, 89 feet per

year; 100 feet depth, 88 feet per year. (Report Chief of Engineers, 1896, App. Q, pl. 1.)

It will be seen from these figures that the average annual advance of the bar has been only about 65 feet, or less than two-thirds the previous rate, and that the curves for 20, 30, and 40 feet depths with which navigation is immediately concerned have only advanced, on an average, 45 feet per annum, or less than half the general advance of the bar before the construction of the jetties.

It was observed that the building of the jetties at the Sulina mouth of the Danube delta retarded instead of accelerating the growth of the bar at its mouth. Sir Charles Hartley, the engineer of the improvement, attributed this to conditions which also prevail to a greater or less extent at the mouth of the South and Southwest Passes of the Mississippi. Under these circumstances there is no reasonable foundation for apprehensions of an excessive or extraordinary increase in the annual rate of extension of the Southwest Pass Bar when improved or of the jetties which should be built across it.

Respectfully submitted.

B. M. HARROD, C. E.,
Member Mississippi River Commission.
HENRY B. RICHARDSON,
Chief State Engineer, Louisiana.

PORT EADS, LA., *February 12, 1898.*

Hon. K. NELSON,
United States Senate, Washington, D. C.

DEAR SIR: In compliance with your request, I have the honor to inform you of the number of days dredging done in the channel from the main Mississippi River to deep water in the Gulf of Mexico during the calendar years 1895, 1896, and 1897, as follows:

	Days.
In 1895	141
In 1896	130
In 1897	108

I think it may interest you to go back still farther with this record and to know where dredging was done and to what extent at each locality. I give you, therefore, the following tabulated statement:

Year.	Number of days dredging in—				Total.	Number of days deficient channel.	Remarks.
	Gulf.	Jetty channel.	South Pass.	Head of South Pass.			
1891	7	57	.....	.....	64	15	Pass a Loutre crevasse occurred in January.
1892	17	56	.....	.....	73	55	
1893	10	22	25	4	61	32	
1894	5	35	25	.....	65	21	
1895	.....	133	8	.....	141	31	Exceptionally low stage of river throughout the year.
1896	2	118	10	.....	130	139	Five rises during the year.
1897	7	68	33	.....	108	62	
Total	48	489	101	4	642	355	

You will learn from the above that there were but forty-eight days during six years when dredging was done to maintain a 30-foot channel from the Gulf end of the jetties to deeper water, and also that the jetty channel required more dredging than was done in all other portions of the channel from the main river to the Gulf.

You will also learn that although Pass a Loutre Crevasse was open in 1891, 1892, 1893, and 1894, the number of days during which a legal channel was not maintained, and the number of days' dredging done, are comparatively small. In 1895 it was also small, but the dredging was 2⅛ times more than the average for the four years previous. In 1896 the dredging was double that done in 1891, 1892, 1893, and 1894, but the time during which the legal channel was not maintained was more than double the average for those four years.

Now, the question arises, why is it that more dredging was required in 1895 than in any of the four preceding years, and why is it that, notwithstanding the dredging done in 1896, the number of days during which a legal channel was not maintained so greatly exceeded those of the five preceding years. What condition has caused this change? I answer that it is mainly due to the stage of the river during those years.

Referring to the hydrographs of the Mississippi River at Carrollton, La., herewith, I will explain briefly that the hills, so to speak, represent the high-river period and the valleys the low-river. Now, in 1891, 1892, 1893, and 1894, we had good high-river periods which, after reaching 12 feet at Carrollton, gave to South Pass all the water that it could carry or that it should be required to carry. In 1895 the river was practically low throughout the year; the two short rises were worse than no rise at all, since they brought down heavy sediment which was left in the channel when the river fell suddenly because, with its decline, the velocity of current decreased until it was no longer able to carry its burden of sediment.

In 1896 a most exceptional stage of river gave us five short rises, each bringing its load of sediment which was deposited in the channel when the river fell as suddenly as it had risen.

In 1897 a good stage of river gave to South Pass sufficient volume and current to remove, in connection with dredging, much of the material deposited, particularly in the jetty channel, during the two preceding years, and this notwithstanding the crevasse was still open.

The deterioration of the works at the head of the Passes, the Pass a Loutre Crevasse, and the stage of the river, are the agents which have influenced the deterioration of South Pass. The stage of river is the prime agent, for I believe that with the crevasse closed and the works at the Head of the Passes as originally built, such rivers as in 1895 and 1896 would not give sufficient volume to South or Southwest Pass to maintain a required channel by the action of the current alone.

I contend, as stated in my evidence before your committee, that after the river reaches 12 feet at Carrollton, South Pass receives all the water that it should carry, but that at intermediate stages the volume lost in consequence of the crevasse or other causes would, if restored, be of great advantage to South Pass. The regulation of the flow of water at the Head of the Passes is one of the most delicate problems that can be given an engineer.

In connection with the improvement of Southwest Pass I would say that eventually the sill across that Pass at its head, or what remains of it, would have to be removed in order to give the requisite volume to that Pass. This need not be done until the works at the mouth are

completed, but when it is done it will still further decrease the flow into South Pass and render the keeping open of both Passes inadvisable.

Very respectfully, your obedient servant,

O. DONOVAN,
Assistant Engineer.

List of cases brought against the United States for damages claimed to arise from the construction and maintenance, or failure to construct or maintain, proper levees along the Mississippi River.

MISSISSIPPI RIVER IMPROVEMENT CASES.

Claimants.	No. of case.	Amount claimed.
Gaulden, Juliet J. and George	20961	$27, 225. 00
Jones, H. W	20962	231, 625. 00
Butler, Alice E	20963	67, 740. 00
Butler, Henry J	20964	.....
Bedford, Thos. C	20514	58, 000. 00
Do	20515	16, 000. 00
Limrall, Lydia Ann, and her husband, Horatio F	19312	30, 000. 00
Hankinson, A. E	19231	3, 000. 00
Jenkins, Alice Dunbar	18996	40, 000, 00
Hutchins, Celeste and Sam'l	18649	3, 645. 00
Glass, Mrs. Mary	18647	3, 000. 00
Hullum, Mary E	18641	3, 645. 00
Hankinson, Wm. S	18619	3, 570. 00
Jackson, Wm. L., (executor)	18274	107, 257. 50
Johnson, Bennie W. and Chas. B	18682	7, 200. 00
Bolb, John L. Alin	18683	12, 179. 00
Gallagher, Charles	17882	37, 250. 54
Jackson, James H. and Katie C	19695	5, 000. 00

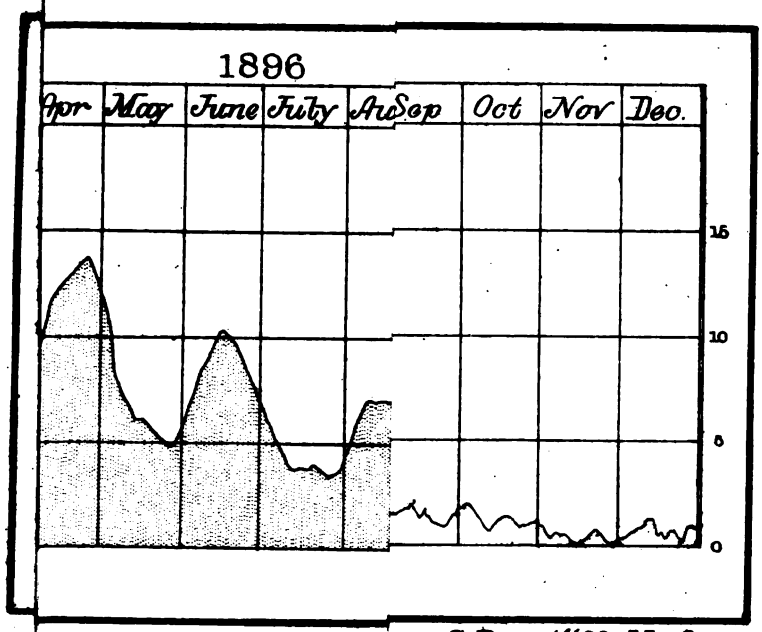
NEW YORK CITY, *March 30, 1898.*

Hon. KNUTE NELSON,
Chairman Senate Subcommittee on Commerce,
United States Senate, Washington, D. C.

SIR: In compliance with your request, I have the honor to send by to-day's mail a table (blue print) showing estimated yardage and cost of levees built by the United States and the several States on the Lower Mississippi River. It is believed that the table approximates closely to accuracy and that you will find it a complete answer to your request.

Very respectfully, your obedient servant,

G. S. GILLESPIE,
Colonel, Corps of Engineers,
President Mississippi River Commission.



S Rep. 1433. 55 3

made available prior to and includ

	Fo					
	Lafourche (length of levee, 75.3 miles			Borgne (length of levee, 80.3 miles).		
	United States since 1893.	By others since 1865.	Tot	States 1893.	By others since 1865.	Total.
Y	698	1, 977, 805	6, 354, 140	8, 3	61, 144	1, 815, 761	2, 676, 905
T	1. 19	$356, 617. 76	$2, 863, 920. 71	$3, 220,	202. 09	$594, 078. 46	$776, 280. 55
Y	888	.....	.....	2, 1	.....	.....	332, 153
Y	810	.....	.....	6, 1	.....	.....	2, 344, 752
Y	120	415, 500	192, 974	6	60, 500	106, 049	166, 549
T	718	2, 393, 305	6, 547, 114	8, 9	21, 644	1, 921, 810	2, 843, 454
E	1. 57	$49, 049. 84	$31, 464. 00	$80,	145. 34	$16, 856. 00	$31, 001. 34
T	1. 76	$405, 667. 60	$1, 895, 390. 71	$2, 301.	347. 43	$610, 934. 46	$807, 281. 89
Y	000	.....	.....	.....	.....	.....	.....
T	898	.....	.....	2, 1	.....	.....	332, 153
T	810	.....	.....	6, 7	.....	.....	2, 511, 301
A	. 05	$49, 766. 12	$21, 188. 20	$70,	647. 70	$6, 129. 85	$41, 777. 55
T	1. 84	$155, 433. 72	$2, 299, 894. 69	$2, 755,	995. 13	$740, 477. 17	$972, 472. 30
Y	412	282, 500	133, 849	4	18, 000	15, 0	333, 036
T	130	2, 675, 805	6, 680, 963	9, 3	39, 644	1, 936, 846	3, 176, 490
T	222	.....	.....	7, 1	.....	.....	2, 844, 337

	Grand total.	
	By others.	Total.
30	84, 948, 791	135, 784, 021
. 53	$29, 634, 474. 01	$40, 011, 573. 54
.....	.....	.....
.....	.....	109, 352, 174
482	7, 288, 718	17, 243, 200
312	92, 237, 509	153, 027, 821
. 48	$1, 477, 089. 22	$2, 931, 140. 70
. 01	$30, 111, 663. 23	$41, 943, 014. 24
.....	.....	.....
.....	.....	27, 523, 723
.....	.....	125, 517, 082
. 43	$672, 809. 78	$2, 162, 167. 21
. 44	$34, 310, 795. 34	$47, 631, 503. 78
119	4, 052, 439	11, 832, 558
431	96, 289, 944	164, 860, 375
.....	.....	137, 329, 636

I. E WATERMAN,
sissippi River Commission.

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